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POTENTIAL IMPACTS OF EXTENDED WINTER NAVIGATION UPON MIGRATORY BIRDS OF THE UPPER U.S. GREAT LAKES

Great Lakes-St. Lawrence Seaway Navigation Season Extension Program

Fish and Wildlife Service
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The purpose of this report is to describe the results of a number of survey and studies conducted in many localities in the Upper U.S. Great Lakes from north western Lake Erie/ Detroit River to the Duluth Superior Harbor complex in western Lake Superior. The projects, conducted both in-house and through contracts, were aimed at determining: (1) both the historical and present winter abundances and distributions of selected species of migratory birds from Lake Superior to the Detroit River, (2) the potential for perturbing riverine/harbor wetlands and benthos communities (and consequences for migratory birds), (3) the extent of bird mortality along selected lakeshore segments, and (4) major migratory pathways of birds in both spring and fall. The projects were oriented toward assessing how ship traffic and disturbance and associated engineering requirements (bubblers, booms, dredging, etc.) would influence bird distribution and movements and their feeding, nesting, and roosting babitats (both summer and winter).

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ERRATA SHEET

Page XVII, item F6:	"Wtland" should be changed to "Wetland".
Page 3, Table 1:	The column headings at the right were omitted - from left to right they should be: Winter Bird Distribution, Winter Mortality, Food Resources, Wetland Impact, Colonial Species Impact, and Migratory Pathways.
Page 4, Paragraph 5:	(Appendix H) should be changed to (Appendix A).
Page 34, Paragraph 5:	"Snowy owls" should be changed to "snowy owl".
Page 36, Paragraph 6:	(Appendix Table B20) should be changed to (Appendix Table B19).
Page 39, Paragraph 2:	"Appendix Table B21" should be changed to "Appendix Table B20".
Page 46, Paragraph 7:	Delete the words "and lake region (e.g. south shore of Lake Superior)" so as to read "A summary of the number of birds seen, by species, for each survey is given in Appendix C".
Page 72, Paragraph 2:	"(Figures 7-22)" and "(Figure 22)" should be changed to "(Figures 5-20)" and" (Figure 20)" respectively.
Page 77, Paragraph 1:	"was presented earlier" should be changed to "will be presented later".
Page 79, Paragraph 2:	"(Figure 4)" should be changed to "(Figure 2)".
Page 85, Paragraph 3:	"(Appendix Table B1)" should be changed to "(Appendix Table B21)".
Page 112, Paragraph 5:	"Table 33" should be changed to "Table 31".
Page 115, Paragraph 2:	Delete one "This".
Page 141, Paragraph 8:	"(Table 47)" should be changed to "(Table 45)".

Page 149, Paragraph 2:	Delete one "area".
Page 149, Paragraph 4:	Delete one "of".
Page 170, Paragraph 2:	"Figure 35" should be changed to "Figure 33".
Page 170, Paragraph 6:	"Figure 36" should be changed to "Figure 34".
Page 182, Paragraph 5:	"Table 63" should be changed to "Table 61".
Page 192, Paragraph 1:	"(Table 67)" and "(see Table 68)" should be changed to "(Table 65)" and "(see Table 66)" respectively.
Page 217, Paragraph 3:	The underlining of "Sewage discharges" should be deleted.
Page 220, Paragraph 5:	"potential" should be changed to "potentially" and "diturbance" should be changed to "disturbance".
Page 223, Paragraph 6:	"habit" should be changed to "habitat".
Page 225, Paragraph 4:	"since" should be capitalized "Since".
Page 227, Paragraph 2:	"pasage" should be changed to "passage".
Page 229, Paragraph 5:	"the" should be capitalized "The".
Page 231, Paragraph 2:	"(Appendix I)" should be deleted - the letter report is not included in this report.
Page 304, Paragraph 6:	Add a period to the first sentence.
Page 319, Paragraph 4:	"Plots #3" should be changed to "Plot #3".
Page 321, Table G15:	"*Typha augustifolia* should be changed to "*Typha angustifolia*".
Page 331, Paragraph 2:	Add a period after the second sentence - after "Lake Manuscong."

POTENTIAL IMPACTS OF EXTENDED WINTER NAVIGATION UPON MIGRATORY BIRDS OF THE UPPER U.S. GREAT LAKES

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DISCLAIMER

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PREFACE

This report is one of several addressing the potential environmental impacts of extended winter shipping activities in the Great Lakes.

Publication of the results will aid resource managers and Corps personnel in deciding how, if necessary, to mitigate impacts upon fish and wildlife resources.

Inquiries about this report should be directed to:

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EXECUTIVE SUMMARY

This report describes the results of a number of surveys and studies conducted in many localities in the Upper U.S. Great Lakes, from northwestern Lake Erie/Detroit River to the Duluth-Superior Harbor complex in western Lake Superior. The projects, conducted both in-house and through contracts, were aimed at determining: (1) both the historical and present winter abundances and distributions of selected species of migratory birds from Lake Superior to the Detroit River, (2) the potential for perturbing riverine/harbor wetlands and benthos communities (and consequences for migratory birds), (3) the extent of bird mortality along selected lakeshore segments, and (4) major migratory pathways of birds in both spring and fall. The projects were oriented toward assessing how ship traffic and disturbance and associated engineering requirements (bubblers, booms, dredging, etc.) would influence bird distribution and movements and their feeding, nesting, and roosting habitats (both summer and winter).

Information garnered from the literature and from aerial and ground surveys conducted from December to March 1979-80 and 1980-81 showed that bird densities and distribution are highly vagile. The severity of the early winter period and the extent of ice cover strongly influence bird populations and their use of certain areas. Nonetheless, a general pattern was that bird populations were highest in the lower lakes (Ontario and Erie) in the Detroit River and at Muskegon and Milwaukee, with the following species present in largest numbers: ring-billed and herring gulls, mallard and black ducks, Canada goose, scaup spp., common goldeneye, oldsquaw, mergansers spp., canvasback, and redhead. Man's activities, including power plant and industrial outfalls and sewage plants, have maintained open water feeding sites, allowing many of the above species to winter further north than they did before the 1930's. Also, feeding programs (e.g., Traverse City, Green Bay) have permitted overwintering of some species in "unusual" areas.

The presence of open water near thermal plumes does not in itself attract birds, however. Apparently, a mosaic of food patches exists, with certain areas used intensively, others not at all. Faunal densities in benthos samples in the Detroit River showed high spatial variability, with depth and sediment characteristics being important. Deep-water areas, such as shipping channels, appear to have quite low food resources. As a result, there is little bird use of the channels.

Of major relevance to winter navigation is concern for ice movement over shallow areas which waterfowl depend upon in the Detroit River. Also, major dredging in the connecting channels and harbors, such as Milwaukee and Muskegon, might destroy the food resources required by waterbirds in winter.

Results of the Great Lakes Beached Bird Survey conducted since 1977 at selected 2-mile survey routes throughout the entire Great Lakes region showed very low rates of recovery of dead birds. In 1979 at 54 survey routes, only 1.14 birds per km were found, in 1980, at 109 routes, only 0.51 birds per km were reported. About 50% of all dead birds were gulls and most of these

were ring-billed gulls. A seasonal pattern in the beaching rate is caused mostly by high mortality of young gulls in late summer and fall before and during migration. Almost no oiling of waterbirds was seen except at one industrial site. These low rates of mortality in non-shipping years will be useful to compare with rates found after intensive winter shipping begins.

Studies conducted in replicated marsh sites in the St. Mary's and in Duluth Harbor were directed at comparing marsh vegetation characteristics in sites remote from shipping with those that have been subjected to both summer and winter shipping throughout the demonstration program (St. Mary's). There were no systematic differences in the two "treatments" (remote vs. "adjacent" sites) as far as overall vegetation characteristics. All marshes had very low species richness and were dominated by Typha, Scirpus spp., and Sagittaria spp., species with generalist characteristics. In general, there was high heterogeneity in "community" characteristics both within and between the two marsh groups. Unless major dredging and/or water level changes occurred as a result of shipping, it is unlikely that wetlands will be adversely affected by winter shipping. Dominance of these wetlands by a few cosmopolitan species suggest that these systems are already adapted to a harsh physical regime.

Recommendations for reducing impacts of winter shipping on migratory birds and their habitats are: (1) Avoid icebreaking, if possible, in areas near shallow water feeding areas for waterfowl, especially in the Detroit River area. Caution should also be exercised near river and bay islands that are subject to high erosion. (2) Exercise caution in the placement of ice booms and other structures in rivers that might affect both water levels and ice damage to shorelines and river bottoms. (3) Minimize dredging especially in areas near productive wetlands. Caution should be used especially in Milwaukee, Muskegon, and Duluth harbors, and the connecting channels.

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Too many individuals contributed to this report to name them all but their contributions are much appreciated. The following individuals directly participated in the actual data collection: University of Michigan (Detroit River project) - Dr. R. Drobney, J. Jones, S. Noseworthy, Long Point Bird Observatory (Great Lakes Beached Bird Survey) - Dr. D. Hussell, A. Lambert, C. Risley, Northwest Michigan College (St. Mary's River project) - Dr. W. Scharf, University of Minnesota (Duluth Harbor Project) - Mr. G. Niemi.

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INTRODUCTION

BACKGROUND

When authorization was granted to the Corps of Engineers to determine the feasibility of extending the navigation period on the Great Lakes throughout the winter, the U. S. Fish and Wildlife Service took on an advisory role through its Fish and Wildlife Coordination Act. There were a number of environmental concerns involving the season extension and the Service wanted to ensure that impacts on fish, wildlife, and their habitat were minimized. Major concerns were: (1) the impact of various engineering structures to be installed in harbors and shipping lanes (e.g., air bubblers, compensating works, ice booms, etc.), (2) the physical disturbance induced by vessel movements, (3) dredging, and (4) hazardous substance spills. The extended navigation season would change many parts of the seaway from a stable, ice-covered system with very low biological activity to one of high perturbation. Vessel movements and all associated activities could have the following ramifications to wildlife and their habitats: (1) dredging could change both aquatic habitats (hence prey bases such as benthos) and terrestrial ones where upland disposal methods were used, (2) wetland habitats might be affected by ice/wave impaction from vessel passage. Deteriorated wetland habitats could have wide-ranging implications for migratory birds during both the migration seasons and the breeding season, (3) the extent of open water as affected by vessel movement during winter and by bubblers could be a significant factor in affecting bird distribution during the winter, and (4) control structures could affect water levels in such areas as the St. Mary's and Detroit Rivers which could, in turn, affect both feeding and nesting habitats of waterbirds.

As part of the U. S. Fish and Wildlife Service's commitment, the Migratory Bird and Habitat Research Laboratory initiated studies in the Fall 1978 to identify key avian components that could potentially be impacted by winter navigation. The following migratory birds were earlier identified as major concerns in regard to potential impacts of winter navigation: bald eagle (*Haliaetus leucocephalus*), osprey (*Pandion haliaetus*), great blue heron (*Ardea herodius*), herring gull (*Larus argentatus*), piping plover (*Charadrius melodus*), ducks, geese, terns, and "other raptors".

With these major groups of birds identified and with the emphasis in the initial stages placed upon the upper three lakes and connecting channels (from the Detroit River to Duluth, Minnesota), a series of studies were outlined to be conducted both by Service personnel and by outside contractors (Table 1).

Aerial surveys were scheduled to periodically (approximately biweekly) inventory the species abundances and distributions on the upper lakes and connecting channels, emphasizing selected shoreline areas and harbor/power plant sites. The major results of the surveys would be useful in indicating major focal areas of bird concentration and to reveal within- and between-year variation in abundances.

A comprehensive literature survey was necessary to synthesize existing data on ·rth winter bird distribution (e.g., Audubon's Christmas Count) and on major migration routes used in spring and fall by all avian species. In many cases, information was not published but existed as records in a number of museum, state and private office files.

Because winter navigation activities might produce additional stresses on birds already confronting physical extremes in winter, support for the continuation and amplification of the Great Lakes Beached Bird Survey was provided. Such long-term monitoring of mortality has been useful in other areas such as the Western U. S. Coast (Ainley et al. 1980)

Many of the physical stresses expected from winter navigation activities such as wave impaction, ice scour and erosion are expected to be greatest at the land-water interface. As a result, studies of wetland habitats and their associated avian fauna were conducted at two sites in the St. Mary's River and in the Duluth-Superior Harbor area. This regime allowed comparisons between two different river systems (St. Louis River and St. Mary's) as well as wetlands in two widely separated geographic areas.

A separate study focused on nesting sites used by colonially nesting gulls, terns, and wading birds in the St. Mary's. There has been concern recently for population declines of certain species such as common terns and loss of nesting habitat due to water level changes, etc.

Because of the historical importance of the Detroit River for wintering migratory waterfowl, a study was initiated to examine the distribution of the birds, their behavior, and to sample their benthic food base over a two-year period in areas of the river with different shipping intensities. The ground surveys of waterfowl using the river could also be compared to the aerial survey results.

STUDY UNITS

Because of the many related but discrete segments of the project, the methods, results, discussion, and summary of each study unit are separated as follows: Unit 1 - Winter bird distribution, Unit 2 - Benthos and food habits; Unit 3 - Breeding birds and their wetland habitats, Unit 4 - Great Lakes beached bird surveys; Unit 5 - Major migration routes and staging areas.

Table 1. Work Units of Present Study.

Studies	Investigator (contractor)						
Aerial surveys	in-house	x					
Literature survey	in-house	x					x
Waterfowl feeding Study (Detroit River)	U. of Michigan[a]	x		x			
Beached bird survey	Long Point Bird Observatory	x	x				
Wetland studies							
St. Mary's River	Northwest Michigan College[b]				x	x	
Duluth-Superior	in-house				x		

[a] Principal investigator, Dr. R. Drobney, School of Natural Resources.
[b] Principal investigator, Dr. W. Scharf, Division of Natural Sciences.

Table 2. Bird Species Included in Winter Distribution Study.

Family	Scientific name	Common name
Gaviidae	*Gavia immer*	common loon
	Gavia arctica	arctic loon
	Gavia stellata	red-throated loon
Podicipedidae	*Podiceps grisegena*	red-necked grebe
	Podiceps auritus	horned grebe
	Podilymbus podiceps	pied-billed grebe
Phalacrocoracidae	*Phalacrocorax auritus*	double-crested cormorant
Ardeidae	*Ardea herodias*	great blue heron
Anatidae	*Olor columbianus*	whistling swan
	Cygnus olor	mute swan
	Branta canadensis	Canada goose
	Chen caerulescens	snow goose
	Anas platyrhynchos	mallard
	Anas rubripes	black duck
	Anas strepera	gadwall
	Anas acuta	pintail
	Anas crecca	green-winged teal
	Anas discors	blue-winged teal
	Anas americana	American wigeon
	Anas clypeata	northern shoveler
	Aix sponsa	wood duck
	Aythya americana	redhead
	Aythya collaris	ring-necked duck

Table 2 (continued)

Family	Scientific name	Common name
	Aythya valisineria	canvasback
	Aythya marila	greater scaup
	Aythya affinis	lesser scaup
	Bucephala clangula	common goldeneye
	Bucephala islandica	Barrow's goldeneye
	Bucephala albeola	bufflehead
	Clangula hyemalis	oldsquaw
	Histrionicus histrionicus	harlequin duck
	Somateria mollissima	common eider
	Somateria spectabilis	king eider
	Melanitta deglandi	white-winged scoter
	Melanitta perspicillata	surf scoter
	Melanita nigra	black scoter
	Oxyura jamaicensis	ruddy duck
	Lophodytes cucullatus	hooded merganser
	Mergus merganser	common merganser
	Mergus serrator	red-breasted merganser
Accipitridae	*Haliaetus leucocephalus*	bald eagle
	Falco rusticolus	gyrfalcon
	Falco peregrinus	peregrine falcon
	Falco columbarius	merlin
Rallidae	*Fulica americana*	American coot
Laridae	*Larus hyperboreus*	glaucous gull
	Larus glaucoides	Iceland gull

Table 2 (concluded).

Family	Scientific name	Common name
	Larus marinus	great black-backed gull
	Larus argentatus	herring gull
	Larus thayeri	Thayer's gull
	Larus delawarensis	ring-billed gull
	Larus philadelphia	Bonaparte's gull
	Larus minutus	little gull
	Pagophila eburnea	ivory gull
	Rissa tridactyla	black-legged kittiwake
Strigidae	*Nyctea scandiaca*	snowy owl

Results

The major sources of data fall into the following categories:

1. Audubon Christmas Bird Counts
2. Mid-winter waterfowl/eagle inventories (state and federal)
3. Records of local observers
4. State bird books and journals
5. Research studies

Of these sources, the first two are by far the most comprehensive, and are the only records which provide long-term, repeated information on wintering populations in specific areas.

Audubon Christmas Bird Counts have been conducted at a number of sites throughout the Great Lakes since the mid-1900's, and, in general, the harbors involved in the winter navigation program have been included for several years (Table 3). Data for Duluth, Milwaukee, Muskegon, and Detroit have been recorded since before 1950, while counts at most other ports considered in the present study are available for at least the past fifteen years.

These data do have some serious limitations as true indicators of wintering populations. Several authors have examined the inherent problems in interpretation of Christmas Counts (e.g., Stewart 1954, Arbib 1967). The underlying problems center around a number of factors including variability in weather and observer competency. Despite recent improvements in this regard, Christmas count data remain of limited use in this study since they do not truly represent wintering populations of waterbirds on the Upper Great Lakes. Most counts are conducted in mid to late December, and many migrants are still present at this time. In mild years, waterfowl may linger well into January. A final limitation of these data is that they represent only one observation per year and, since counts in different areas are not necessarily coincidental, gross errors in overall population figures can occur due to movements of birds.

The other major source of information regarding winter populations of the Great Lakes is the annual mid-winter waterfowl/eagle surveys conducted by state and federal wildlife personnel. This "inventory", conducted in early January, was begun in 1935 by the U. S. Bureau of Biological Survey and seeks to delineate major wintering sites and obtain population indices.

Most shorelines within the Upper Great Lakes have been included in these surveys for several years. The eastern shoreline of Lake Michigan has been censused most years since 1964, while the western shore as far north as Rock Island has been included, although not continuously, since 1956. The Detroit area and associated western Lake Erie have been surveyed since 1947, and most of Lake Huron has been surveyed since 1964. With some exceptions, the U. S. shores of Lake Superior have not been included. In general, harbors have been censused from the ground, while lakeshore has been surveyed from the air. Most Upper Great Lakes harbors having significant winter waterfowl populations have been censused since the early 1950's.

As with the Christmas Bird Counts, the mid-winter surveys are limited in that they take place only one a year, and shifting ice and changing weather conditions can cause major fluctuations in the number of birds observed.

Table 3. Harbors and Other Areas of the Upper Great Lakes Included in Audubon Christmas Counts.

Harbor	Year of First Christmas Count
*Duluth-Superior	1948
Grand Marais	1954 (recent history since 1975)
*Ashland	1978
*Marquette/Presque Isle	1955
*Green Bay	pre-1944 (recent history since 1964)
Sheboygan	1974
*Milwaukee	pre-1944
*Hale's Corners	1956
Racine	1954 (no data since 1968)
Kenosha	1948 (recent history since 1964)
Waukegan	1951
*Chicago Lakefront	1965
*Chicago North Shore	1963
Michigan City	1949 (no data since 1966)
*Calumet	1967
Indiana Dunes	1973
*Muskegon	pre-1944
*Ludington	1966
Traverse City	1960
Rogers City	1973
*Alpena	1966
*Bay City (Saginaw)	1949
*Port Huron	1967
*Anchor Bay	1965 (recent history since 1978)
*Detroit River	1966
*Monroe	1971

*Areas potentially involved in winter navigation.

Furthermore, those portions of the surveys done from the air concentrate on nearshore waters, and pelagic species such as the oldsquaw are not adequately censused.

Many publications regarding winter populations of species of concern in the present study do exist, but most merely reiterate or reformulate information from the two aforementioned sources. Some of these are useful however. Perhaps the single best work was presented by Bellrose (1980). This book presents winter distribution maps, numbers, etc. for all species considered here. Bystrak et al. (1974) presented distribution maps depicting numbers of birds/party-hour derived from Christmas Counts for 1972-73, and Bock (1979) developed a computer system allowing similar maps to be generated from Christmas Count data for the last decade.

A few major publications which present additional original information dealing directly or indirectly with winter bird populations on the Upper Great Lakes exist. Many of these are species-specific, although several site-specific studies have been published also.

The area which has been studied most extensively is the Detroit River and associated Lake St. Clair and St. Clair River. Most publications regarding this area deal with waterbirds, in particular with instances of winter morality due to sudden freezes, disease (botulism), and pollution (e.g., oil spills) (Miller 1948, Hunt 1957, 1961, Hunt and Cowan 1963). They also include distributional information. Utilization of food by waterfowl in Anchor Bay, Lake St. Clair was studied by Dawson (1975), and general bird use of the Detroit River area during the period from 1945 to 1974 was summarized by Kelley (1978).

Winter bird use of the Milwaukee Harbor has also been studied. Rofritz (1972) thoroughly documented spatial and temporal use by oldsquaw and scaup as well as food resource distribution and its relevance to bird distribution within the harbor during the winters of 1970 and 1971. Additional work pertinent to food resources was reported by Ayers and Huang (1967) in which they examined benthic organisms in the Milwaukee embayment.

Avian use of the Duluth-Superior Harbor was studied over the three year period from 1976 through 1979 (Niemi et al. 1977, Davis et al. 1978, Niemi et al. 1979). This work included regular winter bird surveys of the harbor.

Data regarding overwintering goose populations at the Bay Beach Park Wildlife Refuge, the primary winter concentration site in the Green Bay area, have been kept since 1973 (Korb, personal communication). In addition, weekly winter censuses of mallards, black ducks, and geese using the area have been conducted since 1979 (open file data, Bay Beach Park and Wildlife Sanctuary).

Winter use of the St. Mary's River by waterfowl and raptors was studied by Robinson (1979). This study was done under the auspices of the Winter Navigation Board, and directly addressed the impacts of winter navigation on these birds.

Wisconsin Electric Power Company has documented winter bird use of two areas along the Wisconsin shoreline of Lake Michigan (N. Cutright, personal communication). Nine miles of Lake Michigan shoreline from Huntington Beach

up to and including Port Washington were censused weekly during the winter of 1977-78, and a similar section of shoreline near Sheboygan, Wisconsin was censused three times this same winter.

Several studies have been reported regarding select species and various aspects of their winter ecology on the Upper Great Lakes. Although most of these deal specifically with food utilization, they do include useful information on winter distribution also.

The common merganser has been studied from the perspective of potential depredation of trout populations in Michigan. Trautman (1935) documented duck, primarily common merganser, populations concentrated on trout streams of the northern portion of the Lower Michigan Peninsula during the winter of 1934-35. Winter food habits of this species in Michigan were also examined by Leonard and Shelter (1957) and Salyer and Lagler (1940).

Another species which has been studied from the perspective of food utilization is the oldsquaw. Work with this species has principally been restricted to Lake Michigan. Lagler and Wienert (1948), Ellarson (1956), and Peterson and Ellarson (1977) all have published information regarding oldsquaw winter food habits on this lake. Most of the information presented in these works was derived from specimens inadvertently caught in fishing nets, thus some distributional data are presented also.

The mute swan has also been studied, primarily due to the presence of an expanding feral population in the Traverse City, Michigan area. The introduction, growth, and winter distribution of this species have been outlined by Gelston (1970, 1971, 1972).

Due to its federal endangered status, the bald eagle has been of obvious interest, and incidental observations of wintering birds on the Great Lakes have been recorded by various governmental field personnel and other observers. Spencer (1976) presented a summary of past observations of this type as well as those made during Christmas Counts and mid-winter surveys. Since 1979, a more concerted effort to locate overwintering eagles has been undertaken by the National Wildlife Federation in cooperation with state conservation agencies and the U. S. Fish and Wildlife Service. Of those states having appreciable Great Lakes shorelines, only Michigan has organized special searches of likely harbor and shoreline areas. Michigan is also the only state to summarize its findings (Lerg 1979). Minnesota and Wisconsin have compiled data derived from incidental sightings.

Although the snowy owl is a regular winter visitant throughout the Great Lakes, little information regarding its distribution has been published. Hamerstrom (1962) did present a summary of sightings made in Wisconsin during the invasion year of 1961, and similar data for subsequent years have been published by Sindelar (1967) and Nichols (1969). Evans (1980) presented information regarding snowy owl winter populations in the Duluth-Superior Harbor, Lake Superior for the late 1970's. Published reports are lacking for Michigan.

In addition to the above publications, several state bird books exist which contain information about winter bird life in their respective states (Barrows 1912, Roberts 1932, Gromme 1933, Wood 1951, Tessen 1976, and Green and Janssen 1975). In general, these sources rely on and summarize the observa-

tions and impressions of their authors and a multitude of local observers. For the most part, the information is qualitative in nature, although specific locations of overwintering concentrations are often given. Most useful in this regard are the books by Tessen (1976), which outlines concentration areas along the Wisconsin shoreline of Lake Michigan, and Green and Janssen (1975), which presents excellent information on abundance and distribution of overwintering species on the Minnesota shore of Lake Superior.

Lake Superior

No comprehensive studies of winter bird use of Lake Superior were found. General information comes primarily from state bird books and the state ornithological journals of Minnesota and Wisconsin. Green and Janssen (1975) and Roberts (1936) provide summaries for the Minnesota portion of the lake, while Gromme (1933) presents general observations regarding the Wisconsin shoreline. The Loon and Passenger Pigeon, publications of the Minnesota and Wisconsin ornithological societies, respectively, provide numerous references and winter season summaries for the last several decades. Almost all available information deals with near-shore and harbor areas. Data regarding bird use of pelagic zones are limited. The following accounts are derived from the above sources as well as any site-specific studies which have been conducted on the lake.

Winter bird use of Lake Superior is generally low, and no areas of major concentration exist. Table 4 lists those species (including waterbirds, gulls, and raptors) observed during winter months. Most records come from the north shore of the lake. This is partially due to the fact that relatively little observation has taken place on the south shore, but also reflects ice conditions as the prevailing winter winds keep the southern shoreline icebound and the northern shore ice-free much of the winter.

While the lake is known for unusual bird sightings (e.g., Iceland gull, ivory gull, eider spp.), only three species occur in significant numbers. These are the common goldeneye, oldsquaw, and herring gull. Two additional species, the common merganser and snowy owl, are regular winter visitants but occur in low numbers.

The common goldeneye is most often seen in scattered groups of 10 or less, and is found throughout open shoreline areas and harbors. Bellrose (1980) estimates that approximately 500 individuals overwinter on Lake Superior. These birds are known to migrate daily between the lake and open inland waters, especially tributary rivers. Typically the birds will feed on the rivers during the day, and return to the lake to roost.

The oldsquaw utilizes offshore areas and is most commonly seen along the Minnesota shoreline of Cook County--in particular Good Harbor Bay. This species usually occurs in rafts of 30-100 birds and large populations inhabit the lake during some winters. In February, 1961, over 1000 oldsquaw were seen between the municipalities of Tofte and Grand Marais, a 48 km length of shoreline. The extent to which this species uses areas large distances from shore is unknown, but oldsquaws typically feed at depths of 30 meters or more on Lake Michigan (Ellarson 1956). Thus individuals may use areas up to a few miles offshore.

Table 4. Winter Bird Species of Lake Superior[a].

Common name	Winter status[b]	Abundance[c]
GAVIIDAE		
Red-throated loon	Accidental-visitant	Rare
PODICIPEDIDAE		
Red-necked grebe	Accidental-visitant	Rare
Horned grebe	Casual-visitant	Rare
ANATIDAE		
Mallard	Regular-permanent	Locally uncommon
Black duck	Regular-permanent	Rare
Pintail	Accidental-permanent	Rare
Ring-necked duck	Casual-permanent	Rare
Canvasback	Accidental-visitant	Rare
Scaup spp.	Regular-straggler	Uncommon
Common goldeneye	Regular-permanent	Common
Barrow's goldeneye	Casual-visitant	Rare
Oldsquaw	Regular-visitant	Common
Harlequin duck	Regular-visitant	Rare
Common eider	Accidental-visitant	Rare
King eider	Accidental-visitant	Rare
White-winged scoter	Casual-visitant	Rare
Surf scoter	Accidental-visitant	Rare

Table 4 (continued)

Common name	Winter status[b]	Abundance[c]
Black scoter	Accidental-visitant	Rare
Common merganser	Regular-permanent	Uncommon
Red-breasted merganser	Regular-straggler	Uncommon
ACCIPITRIDAE		
Goshawk	Regular-permanent	Rare
Sharp-shinned hawk	Casual-permanent	Rare
Red-tailed hawk	Casual-permanent	Rare
Rough-legged hawk	Regular visitant	Rare
Bald eagle	Regular-permanent	Rare
FALCONIDAE		
Gyrfalcon	Casual-visitant	Rare
Peregrine falcon	Accidental-visitant	Rare
LARIDAE		
Glaucous gull	Casual-visitant	Uncommon
Iceland gull	Accidental-visitant	Rare
Herring gull	Regular-permanent	Common
Thayer's gull	Casual-visitant	Rare
Ivory gull	Accidental-visitant	Rare
Black-legged kittiwake	Accidental-visitant	Rare
STRIGIDAE		
Great horned owl	Regular-permanent	Rare
Snowy owl	Regular-visitant	Uncommon

Table 4 (concluded).

Common name	Winter status[b]	Abundance[c]
Barred owl	Regular-permanent	Rare
Long-eared owl	Casual-visitant	Rare
Boreal owl	Regular-visitant	Rare
Saw-whet owl	Casual-permanent	Rare

[a]Derived from historical records and present study.
[b]Accidental - occurs rarely, Casual - occurs some years, Regular - seen almost all years; Visitant - not present as breeding bird, Straggler - late migrant; Permanent - some individuals (though not necessarily the same) present year-round.
[c]Rare - <10 per observer day, Uncommon - 10-100, Common - 100-1000, Abundant - >1000.

Overwintering herring gulls tend to congregate near harbors, municipalities, and/or garbage dumps. In early winter, flocks as large as 1000 birds have been observed, but groups of a few hundred or less are more common during the January-February period. Most of the harbors on Lake Superior are used during the winter.

The bald eagle is a rare visitant on Lake Superior, but is often seen on Christmas counts and during March in harbor areas. There is no evidence that individuals actually overwinter at any of these sites, and the birds observed are probably stragglers.

The snowy owl is another regular winter visitant, although its numbers fluctuate widely due to irregular "invasions" from the north. This species is most often seen in harbors, especially Duluth-Superior, where dense prey populations (e.g., feral pigeons) are present.

The peregrine falcon, a federally endangered species, is seen with some regularity during the winter. In recent years, regular sightings have been reported from Duluth and the nearby areas of the northern shoreline (Green and Janssen 1975). As with the snowy owl, this species may be attractd by abundant prey populations present in harbors.

Grand Marais

No previous site-specific studies of winter bird use of this harbor or adjacent portions of Lake Superior were found. Christmas Count data are available for the years from 1954 to 1957 and 1975 to the present. The Grand Marais Christmas Count area includes the harbor and portions of Lake Superior. Hence count data are probably representative of early winter bird use of the area. Data for the past seven years are presented in Appendix Table B1. Additional data are available from sporadic observations made by birdwatchers, and, since this is a favored winter birdwatching area, records are numerous. These are summarized in Green and Janssen (1975).

Winter waterbird use of this harbor is restricted to December and early January since it is icebound the remainder of the season. During the open water period, all winter species recorded for Lake Superior (Table 4) may occur here, but it is unlikely that bird use is significant with the exception of occasional visits by groups of gulls and small mixed groups of mallard and black duck. The nearby waters of Lake Superior are noted for oldsquaw.

Taconite Harbor

No previous site-specific studies of winter bird use of this harbor or adjacent portions of Lake Superior were found. The only data available come from sporadic observations made by birdwatchers and are summarized in Green and Janssen (1975).

Winter waterbird use of the harbor proper is limited to late December and early January since it is icebound the remainder of the season. All winter species recorded for Lake Superior (Table 4) may occur in this area, but it is unlikely that winter use is significant with the exception of regular visits by groups of gulls.

Silver Bay

No previous site-specific studies of winter bird use of this harbor or adjacent portions of Lake Superior were found. The only data available come from sporadic observations made by birdwatchers and are summarized in Green and Janssen (1975). Winter waterbird use of the harbor proper is limited to late December and early January since it is icebound the remainder of the season.

All winter species associated with Lake Superior (Table 4) may occur here, but it is unlikely that use is significant with the exception of regular visits by groups of gulls.

Two Harbors

No previous site-specific studies of winter bird use of this harbor or adjacent portions of Lake Superior were found. The only data available come from sporadic observations made by birdwatchers and are summarized in Green and Janssen (1975). Winter waterbird use of the harbor proper is limited to late December and early January since it is icebound the remainder of the season. All winter species associated with Lake Superior (Table 4) may occur here, but it is unlikely that use is significant with the exception of regular visits by groups of gulls.

Duluth-Superior

Winter bird use of the Duluth-Superior harbor was documented during a three year study of bird use of the harbor conducted by the University of Minnesota, Duluth (Niemi et al. 1977, Davis et al. 1978, and Niemi et al. 1979). Additional observations are summarized by Green and Janssen (1975) and in Christmas Count reports. The Duluth Christmas Count area includes a portion of the harbor and some Lake Superior shoreline. Hence count data are probably representative of early winter use of the area. Data are available for the last several decades, and the last 20 years are summarized in Appendix Table B2.

Winter bird use of this harbor is sparse, although it is known for rare and unique sightings. The only open water areas are found near the wastewater treatment plant, the Minnesota Power Hibbard power plant, and the entryways into the harbor. These open areas are small (< 1 hectare), and waterbird use is limited to a few common goldeneyes and mergansers and irregular visits by species such as the oldsquaw and harlequin duck. The total waterbird population is usually less than 20 individuals. All of these birds regularly migrate between the harbor and nearby areas of Lake Superior.

A moderate number of gulls, primarily herring, use the harbor during the early winter. They appear to be attracted by food sources at the Duluth and Superior landfills. As many as 100 birds remain in the area until mid-January. Several unique gull species are seen regularly also.

Several raptor species have been observed in the harbor during the winter months, although only the snowy owl occurs in significant numbers. Regular winter residents include the red-tailed hawk, rough-legged hawk, great horned owl, and snowy owl. The first three species are usually represented by only one or two birds, while the snowy owl population ranges from only a few to

nearly 50 individuals (D. Evans, personal communication). The latter species is found primarily near grain storage elevators at the Port Terminals, although sightings have been made throughout the harbor (Niemi et al. 1979).

The bald eagle does not overwinter in the harbor, but is commonly seen in late winter and spring. This species uses several areas within the harbor including Allouez Bay and Spirit Lake and is often observed feeding on fish near the open water areas.

Ashland

No previous site-specific studies of winter bird use of this harbor and adjacent Chequamegon Bay were found. Christmas Count data are available from 1972 to the present (Appendix Table B3). Additional data are available from local observers.

The harbor and most of Chequamegon Bay are normally icebound by late December. Waterbird use of the area is primarily restricted to open water sites, including small areas at the mouth of Fish Creek and the outflow of the Lake Superior District Power Company power plant. Wisconsin DNR personnel report that a small flock of mallards occasionally overwinter at Fish Creek. The mute swan was artificially introduced in the early 1900's and breeds in the marshes along Fish Creek. It appears that breeding birds remain throughout the winter. An occasional snowy owl has been seen at Fish Creek also (Tessen 1976).

Bald eagles are regularly seen here during Christmas Counts, but sightings have not been reported beyond the migration period. Several active bald eagle nests have been found in the Chequamegon Bay area in recent years and Christmas sightings probably represent breeding birds which have not yet migrated.

Marquette/Presque Isle

Ice cover in these two adjacent harbors is quite changeable, although the lower Dead River and a small area at the generating plant outfall in Marquette remain open throughout the winter. Information regarding winter bird use comes from two sources - Audubon Christmas Counts and a one-year study of wintering waterfowl conducted by Pykosz (in prep.). Pykosz found that the total waterfowl population was usually less than 100 individuals and included common goldeneye, common merganser, bufflehead, and Canada goose. These birds primarily used the lower Dead River. Use of the power plant site was low.

Christmas count data for the area are available from 1955 to the present (Appendix Table B4). Species observed, in addition to those mentioned above, include gulls (predominantly herring) and an occassional bald eagle or snowy owl. All winter species reported for Lake Superior (Table 4) may occur here.

St. Mary's River

Winter bird use of the St. Mary's River and adjoining portions of Lakes Superior and Huron was documented by Robinson and Jensen (1979) during the winter of 1978-79. Their study included nine aerial surveys conducted at

approximately one week intervals from early January until April. The total population ranged from 500 to 1000 birds. Species observed during the January-February period are listed in Table 5. The most abundant were the common goldeneye, mallard, common merganser, and Canada goose. The remaining species were represented by less than 10 individuals.

Areas of bird concentration included the open water areas near Bellevue Park, the St. Mary's River Rapids, the Edison Soo hydro outfall, and areas along the north shore of the North Channel. One or two bald eagles were sighted often during the study. No other site-specific studies of winter bird use of the St. Mary's River were found, although the St. Mary's River has been censused as part of the continental mid-winter survey since 1964. Species reported generally agree with those already noted.

Lake Michigan

General information regarding winter bird use of Lake Michigan comes from state bird books (Barrows 1912, Wood 1943, Gromme 1963, Tessen 1976), ornithological journals of bordering states, Christmas Bird Counts, and continental mid-winter surveys. In addition, site-specific studies have been conducted at Green Bay, Port Washington, Sheboygan, Milwaukee, and Traverse City. Almost all available information deals with near-shore and harbor areas hence data regarding the pelagic zone are lacking.

The open waters of Lake Michigan, including harbors, drowned river mouths, and open shoreline areas, serve as wintering grounds for several thousand birds representing many species, but on a continental basis it is not considered an important wintering area for birds. The fact that the west shore remains open most winters as a result of westerly prevailing winds, whereas the east shore is usually icebound. The west shore also is more highly developed, and several industrialized harbors remain open much of the year, (e.g., Milwaukee). Sites known for large winter bird concentrations include the city of Green Bay and associated Fox River, Milwaukee, and Kenosha on the west shore and Muskegon and Traverse City on the east shore.

Winter bird species of Lake Michigan are listed in Table 6. Several species are considered locally abundant, including the mallard, scaup spp., oldsquaw, common goldeneye, and Canada goose. Other common species are the red-breasted and common merganser, bufflehead, and black duck. Species of special interest include the bald eagle and snowy owl.

Mallards are abundant in many areas along the lake, but primarily occur where residents feed them and/or at power plant sites and harbors. These sites are many and include Green Bay, Milwaukee, several locations in the general Chicago area, and Traverse City. The distribution of the black duck is much the same as the mallard, although it is far less abundant. The largest concentration of black ducks is at Green Bay (ca. 400).

Both lesser and greater scaup are present during the winter, but the former is generally uncommon or rare on the upper Great Lakes. Difficulty in differentiating these two species makes records questionable, therefore, they are often lumped. Observations indicate that scaup are most abundant along the

Table 5. Species of Waterfowl Observed on the St. Mary's River, January-February, 1979 (adapted from Robinson 1979).

Common name	Abundance
Canada goose	14 individuals
Mallard	375
Black duck	<10
Common goldeneye	100-350
Bufflehead	<10
Common merganser	50-70
Wood duck	<10
Harlequin duck	<10

Table 6. Winter Bird Species of Lake Michigan[a].

Common name	Winter status[b]	Abundance[c]
GAVIIDAE		
Common loon	Casual-visitant	Rare
Red-throated loon	Accidental-visitant	Rare
PODICIPEDIDAE		
Horned grebe	Casual-visitant	Rare
ARDEIDAE		
Great blue heron	Casual-visitant	Rare
ANATIDAE		
Mute swan	Regular-permanent	Locally abundant
Canada goose	Regular-visitant	Locally abundant
Mallard	Regular-permanent	Locally abundant
Black duck	Regular-permanent	Locally uncommon
Gadwall	Casual-visitant	Rare
Pintail	Casual-visitant	Rare
Northern shoveler	Casual-visitant	Rare
American wigeon	Casual-visitant	Rare
Redhead	Casual-visitant	Locally uncommon
Ring-necked duck	Casual-visitant	Rare
Scaup spp.	Regular-visitant	Locally abundant
Canvasback	Casual-visitant	Rare
Common goldeneye	Regular-visitant	Common
Bufflehead	Regular-visitant	Uncommon
Oldsquaw	Regular-visitant	Abundant-sometimes local

Table 6 (continued)

Common name	Winter status[b]	Abundance[c]
Common eider	Accidental-visitant	Rare
King eider	Accidental-visitant	Rare
White-winged scoter	Casual-visitant	Rare
Surf scoter	Casual-visitant	Rare
Black scoter	Accidental-visitant	Rare
Ruddy duck	Accidental-straggler	Rare
Hooded merganser	Casual-visitant	Rare
Common merganser	Regular-visitant	Common (locally abundant)
Red-breasted merganser	Regular-visitant	Common
ACCIPTRIDAE		
Goshawk	Casual-visitant	Rare
Sharp-shinned hawk	Casual-permanent	Rare
Red-tailed hawk	Casual-permanent	Rare
Rough-legged hawk	Casual-visitant	Rare to irregularly uncommon
Bald eagle	Regular-permanent	Rare
Golden eagle	Accidental-visitant	Rare
Marsh hawk	Casual-visitant	Rare
FALCONIDAE		
American kestrel	Regular-visitant	Rare
RALLIDAE		
American coot	Casual-visitant	Rare

Table 6 (concluded).

Common name	Winter status[b]	Abundance[c]
LARIDAE		
Glaucous gull	Accidental-visitant	Rare
Iceland gull	Accidental-visitant	Rare
Great black-backed gull	Regular-visitant	Rare
Herring gull	Regular-permanent	Locally abundant
Ring-billed gull	Regular-permanent	Locally common
Bonaparte's gull	Accidental-visitant	Rare
STRIGIDAE		
Great horned owl	Regular-permanent	Rare
Snowy owl	Regular-visitant	Locally uncommon
Hawk owl	Accidental-visitant	Rare
Barred owl	Casual-permanent	Rare
Long-eared owl	Casual-permanent	Rare
Boreal owl	Accidental-visitant	Rare
Saw-whet owl	Casual-permanent	Rare

[a]Derived from historical records and present study.
[b]Accidental - occurs rarely, Casual - occurs some years; Regular - seen almost all years, Visitant - not present as breeding bird, Straggler - late migrant, Permanent - some individuals (though not necessarily the same) present year-round.
[c]Rare - <10 per observer day; Uncommon - 10-100, Common - 100-1000, Abundant - >1000.

western shoreline of the lake, in particular the Milwaukee area. Bellrose (1980) indicates that about 8000 birds use the west side of the lake. Usually approximately 2000 birds are seen on the Wisconsin shoreline (exclusive of harbors) during the mid-winter surveys. Christmas Count data and unconfirmed reports of fishermen indicate that large rafts can be found throughout the lake including areas several kilometers offshore.

The oldsquaw is probably the most abundant winter species. This species feeds up to several kilometers offshore in deep waters (Ellarson 1956) and can be found in any portion of the lake. In general, the largest number of birds have been seen along the western shore. The single largest area of concentration is Milwaukee harbor where several thousand birds overwinter. Large numbers have also been reported during Christmas Counts at Racine, Kenosha, and Waukegan. Approximately 2000 to 3000 birds are tallied during mid-winter surveys of the west shore. Significant numbers (ca. 1000) are seen on the east shore during mid-winter surveys, but generally the numbers are quite low. Bellrose (1980) estimates that nearly 12,000 oldsquaws winter on Lake Michigan. In contrast to open lake areas where this species feeds primarily on Ponteporia affinis (Ellarson 1956), sludge worms are a large portion of the diet in Milwaukee (Rofritz 1972). Other open harbors along the west shore support wintering oldsquaw on occasion (e.g. Port Washington).

The winter population of mute swans is found almost exclusively at Traverse City, although single birds are occasionally observed in other harbors.

Like the mallard, wintering Canada geese are primarily found in areas where they are fed by residents. Several of these sites exist, but they are most common in the Chicago area and western shore in general, although several additional concentrations are present inland. Perhaps the largest concentration directly associated with the lake is found at Bay Beach park Wildlife Refuge, Green Bay. Several hundred birds overwinter at this site.

Other common species include the common goldeneye, common merganser, and red-breasted merganser. All three of these species occur in scattered flocks throughout open shoreline areas. The common merganser also congregates in some areas, including power plant sites and open tributary rivers, where fish are available (Salyer and Lagler 1940). Bellrose (1980) estimates that 14,000 goldeneyes winter on Lake Michigan.

The most common gull species are the herring gull and ring-billed gull. While they can be seen in scattered groups in almost any shoreline area, they are most abundant near harbors and/or garbage dumps where they feed. Power plant sites also attract large numbers of gulls. Several additional larids have been observed on the lake including such "rare" and "unique" species as the Iceland gull.

Several raptor species occur along the shorelines of Lake Michigan, although the only species represented by more than a few individuals is the snowy owl. This species is most often observed in harbor areas. The population fluctuates widely due to irregular invasions from the north, but several individuals usually overwinter in Green Bay and Milwaukee. The bald eagle is a rare winter species on Lake Michigan. The total population reported for

Lake Michigan shoreline areas has been under 15 birds in recent years (Lerg 1979). Sightings of this species are scattered and it is not known whether they are resident birds or migrants.

Escanaba

No previous site-specific studies of winter bird use of this harbor or adjacent portions of Little Bay de Noc were found, nor has this area been included in Christmas Counts or the mid-winter survey. The only data available are observations made by birdwatchers and other interested parties.

The harbor and adjoining Little Bay de Noc are icebound from mid-January to April, hence waterbird use during the winter is confined to the small open water areas in the Escanaba River and at the power plant. Small numbers of scaup, common goldeneye, bufflehead, common merganser, and herring gull use these sites. Other species which have been observed include the snowy owl and bald eagle. It is not known whether the bald eagle sightings (single birds only) represent breeding birds, although adults have been observed.

Green Bay (City)

Lower Green Bay is usually icebound from December until April, however open water is present at the mouth of the Fox River where heated effluent from the Pulliam power plant is discharged. The Upper Fox River, only a few kilometers distant, also remains open most of the year. In addition, artificial ponds at the Bay Beach Park Sanctuary are kept open throughout the winter months. Waterbird use is primarily restricted to these areas. The most abundant species are the mallard, black duck and Canada goose. Beginning in 1977, personnel from Bay Beach Park Sanctuary conducted weekly winter censuses of mallard, black ducks, and geese inhabiting the park and nearby open water at the Pulliam power plant (Tables 7 and 8). In recent years, winter populations of these species have been near 1800, 400, and 800, respectively (Table 8). These species are almost entirely dependent upon feeding at the sanctuary, however, they migrate diurnally between open water areas, but also will move to open shoreline along Lake Michigan and open waters on the Oconto River. (T. Erdman, personal communication). Use of the water at the Pulliam power plant is greatest at dawn and dusk (Korb, personal communication).

Other species which occur in significant numbers include the common merganser (ca. 100), common goldeneye (ca. 30), and herring gull (ca. 150). Mid-winter surveys of the Fox River include significant numbers of mallards, and black ducks, but it is likely that most of these birds come from the Bay Beach flock. Goldeneyes are also found in this area.

The Green Bay Audubon Christmas Count area includes sites used by winter birds, and available data span several decades. A summary of the last 16 years is presented in Appendix Table B5. The snowy owl is a regular winter visitor in the harbor area, and as many as eleven have been reported in Christmas Counts. These birds have been sighted at several locations throughout the lower bay and Fox River, but are most commonly seen within 1/2 km of the mouth of the river.

Table 7. Average Winter Canada Goose Population[a] at Beach Bay Wildlife Sanctuary, Green Bay, 1977-1981 (open file data).

Month	1977	1978	1979	1980	1981
January	416(4)	486(4)	727(4)	778(4)	-
February	355(4)	479(3)	753(4)	-	-
March	375(5)	372(5)	615(5)	-	-

[a]Number of censuses in parentheses.

Table 8. Winter Duck Populations at Beach Bay Wildlife Sanctuary, Green Bay, 1979-1980.

Month	1979-80 Mallard	1979-80 Black duck
Early January	1829	348
Late January	1974	466
Early February	No data	No data
Late February	2032	370
Early March	1618	379

Two Rivers

No site-specific studies of winter bird use of this harbor or adjacent portions of Lake Michigan were found. Tessen (1976) states that an assortment of ducks, loons, grebes, and gulls frequent the harbor during the winter. All winter species recorded for Lake Michigan (Table 6) are likely to occur at sometime, although there is no evidence that bird use is significant.

Manitowoc

No site-specific studies of this harbor or adjacent portions of Lake Michigan were found. Tessen (1976) states that hundreds of common goldeneye and oldsquaws as well as occasional white-winged scoters and harlequin ducks can be seen in the harbor during winter. All winter species recorded for Lake Michigan (Table 6) may occur in this area on occasion.

Sheboygan

Wisconsin Electric Power Company conducted a study of bird use, including the winter months, of approximately 27 kilometers of shoreline immediately north of and including this harbor during the winters of 1974 and 1978. The most abundant January species were the common goldeneye, oldsquaw, and herring gull (Table 9). The Sheboygan Christmas Count area does include a portion of the harbor and adjacent lakeshore. These data are available for the last several years. A summary of the data is presented in Appendix Table B6. The most common species are the common goldeneye, oldsquaw, and herring gull. All winter species recorded for Lake Michigan may occur in this area (Table 6).

Port Washington

This harbor remains ice-free most of the winter due to heated effluent from the local power plant. To assess the effect of this plant on bird distribution, Wisconsin Electric Power Company conducted a study of bird use, including the winter months, of approximately 14 kilometers of Lake Michigan shoreline from Harrington Beach Park up to and including the harbor of Port Washington (1977-78). The study consisted of weekly surveys. Common species within the harbor included the herring gull, ring-billed gull (late winter), scaup spp., common goldeneye, oldsquaw, and common merganser (Table 10).

Milwaukee

A great deal of information pertaining to winter birds in this harbor and adjacent Lake Michigan is available due to its reputation as a site of large bird concentrations. This site is probably the most important waterbird area on all of Lake Michigan. Tessen (1976) states that large numbers of oldsquaw, buffleheads, scaup spp., common goldeneyes, red-breasted mergansers, herring gulls, and ring-billed gulls can be observed here at different times during most winters. Moderate numbers of snowy owls regularly use this harbor during the winter also (Sindelar 1965).

Portions of the Milwaukee harbor are included in two Christmas count areas. Data are available for the last several decades, and a summary of the last 20 years is presented in Appendix Tables B7 and B8. Particularly noteworthy are the large number of oldsquaw and scaup, the dominant winter species.

Table 9. Summary of January Waterbird Surveys Conducted by Wisconsin Electric Power Company Along Lake Michigan in the Vicinity of and Including the Sheboygan, Wisconsin Harbor.

Species	Number of birds[a] 1974	1978
Mallard	4	--
Scaup spp.	3	--
Common goldeneye	275	183
Oldsquaw	416	40
Common merganser	43	19
Red-breasted merganser	23	--
American coot	2	--
Gull spp. (primarily herring)	827	138

[a]Total sited at 10 observation points including the harbor and ca. 27 kilometers of shoreline north of the harbor.

Table 10. Summary of Winter Waterbird Survey Conducted by Wisconsin Electric Power Company Along 14 Kilometers of Lake Michigan Shoreline Including the Port Washington Harbor 1977-78.

Species	Number of birds[a]					
	January		February		Early March	
	Harbor	Shore	Harbor	Shore	Harbor	Shore
Mallard	18	0	14	2	27	0
Black duck	7	0	4	1	3	0
Gadwall	+	0	1	0	1	0
Redhead	0	0	0	0	3	0
Canvasback	1	0	0	0	0	1
Scaup spp.	65	7	44	0	38	0
Common goldeneye	93	165	157	113	98	22
Bufflehead	1	+	3	1	2	0
Oldsquaw	35	122	32	48	54	5
White-winged scoter	0	0	0	0	0	44
Hooded merganser	1	0	1	0	1	0
Common merganser	119	7	84	14	48	56
Red-breasted merganser	7	7	2	5	1	3
Herring gull	68	8	116	139	76	53
Ring-billed gull	0	0	21	1	7	4

[a]Mean of all counts made during month (12-5) rounded to nearest integer; + present at < 0.5 birds per count.

Total populations exceeding 20,000 are not uncommon for Christmas counts, although recent figures have been somewhat lower.

Spatial utilization of the harbor reflects both ice conditions and food resources. While it is not uncommon for the harbor to be covered by ice at various times during the winter, open water almost always exists near the mouth of the Milwaukee River's and immediately outside the breakwater structures. Furthermore, the ice periodically disappears with changing winds and weather conditions.

Rofritz (1972) studied spatial and temporal utilization of the harbor by ducks during the winters of 1970-71 and 1971-72. A summary of species present and their abundance is given in Table 11. This study concentrated on the oldsquaw and scaup. The study also showed that these birds react strongly to human activity, especially boating. The winter populations of scaup remained nearly constant during the two winters of the study, indicating that Christmas count totals, although substantially lower than "actual" populations, may be good relative indicators of overwintering birds in this harbor.

Racine

No site-specific studies of winter bird use of this harbor or adjacent Lake Michigan were found. Tessen (1976) states that various diving ducks and gulls frequent the harbor during the winter, although he presents no abundance data. The predominant species include the mallard, common goldeneye, oldsquaw, and herring gull. All are represented by several hundred individuals most winters. All winter species reported on Lake Michigan may occur here (Table 6). The Racine Christmas Count area includes the harbor and adjacent shoreline of Lake Michigan. These data are available from 1954 to the present and the last 20 years are summarized in Appendix Table B9.

Kenosha

No site-specific studies of winter bird use of this harbor or adjacent Lake Michigan were found. Tessen (1976) reports that scaup and all three scoters have been observed in the entrance channel during winter. He also states that rafts of more than 1200 oldsquaws can be seen near the north pier every winter, and up to 400 red-breasted mergansers are often seen near the American Motors plant. Additional winter species reported by Tessen include hooded and common mergansers, buffleheads, canvasbacks, American wigeon, and gadwall.

The Kenosha Christmas Count area includes portions of the harbor and adjacent Lake Michigan. These data are available for most years during the last several decades (the last 17 years are summarized in Appendix Table B10). These data differ somewhat from Tessen's, although this may only reflect the fact that the count includes only one day. Count data show the dominant species to be the common goldeneye, oldsquaw, and herring gull. Each of these has been represented by several hundred birds during most winters. All winter species reported for Lake Michigan may occur in this area (Table 6).

Table 11. Status of Birds[a] Observed in Milwaukee Embayment During 1970-71 and 1971-72 Seasons.

Species	Winter 1970-71	Winter 1971-72
Horned grebe	0	0
Pied-billed grebe	R	R
Mute swan	0	VR
Canada goose	0	VR
Blue goose	0	VR
Mallard	C	C
Black duck	C	C
Pintail	R	R
American wigeon	R	R
Shoveler	0	0
Blue-winged teal	R	R
Green-winged teal	R	R
Wood duck	VR	VR
Redhead	R	R
Canvasback	R	R
Ring-necked duck	R	R
Greater scaup	C	C
Lesser scaup	FC	FC
Common goldeneye	C	C
Barrow's goldeneye	0	VR
Bufflehead	FC	FC
Oldsquaw	C	C
Surf scoter	0	0
Ruddy duck	R	R
American merganser	R	R
Red-breasted merganser	C	C
Hooded merganser	R	R
American coot	FC	FC

[a]Taken from Rofritz (1972), C = common, FC = fairly common, R = rare, VR = very rare, 0 = not present.

Chicago

No site-specific studies of winter bird use of this harbor or adjacent Lake Michigan were found, but The Chicago Lakefront Christmas Count, which covers only harbors and lakeshores, usually reports large numbers of mallard, common goldeneye, and gull spp., including Bonaparte's (Appendix Table B11). The Chicago North Shore count area also includes large number of these species as well as oldsquaw (Appendix Table B12). Total populations are typically in the thousands, however these data may be representative of early winter bird use. All winter species recorded for Lake Michigan may occur here (Table 6).

Burns Waterway

No site-specific studies of winter bird use of this harbor were found. Industrial development within the area has essentially eliminated bird use, although waterbirds may occasionally be found in the nearby waters of Lake Michigan.

Gary

No site-specific studies of winter bird use of this harbor or adjacent Lake Michigan were found. This site is heavily industrialized and bird use is probably limited to occasional use by waterfowl and gulls. All winter species reported for Lake Michigan (Table 6) may occur in the area. The Indiana Dunes Christmas Count area is located nearby, and count data are probably representative of early winter use of the Gary area. These data have been recorded since 1973 and are summarized in Appendix Table B13. Total waterbird numbers of several hundred are common. The predominant species are the Canada goose, mallard, common goldeneye, bufflehead, herring gull, and ring-billed gull.

Calumet

No site-specific studies of winter bird use of this harbor or adjacent Lake Michigan were found. Bird use is probably limited to occasional waterfowl and gulls. All winter species reported for Lake Michigan may occur in the area (Table 6). The Calumet Christmas Count area includes the harbor, and count data are available from 1967 to the present (Appendix Table B14). Several hundred waterfowl are usually observed, including the mallard, common goldeneye, and many other species.

Indiana Harbor

No site-specific studies of winter bird use of this harbor or adjacent Lake Michigan were found. The area is heavily industrialized and bird use is probably limited to occasional waterfowl and gulls. All winter species reported for Lake Michigan may occur in the area (Table 6).

Michigan City

No site-specific studies of winter bird use of this harbor or adjacent portions of Lake Michigan were found. The Michigan City Christmas Count area does include portions of the harbor and adjacent lakeshore and data are

available from 1949 to 1966. Counts from 1960 through 1966 are summarized in Appendix Table B15. Total waterbird populations are generally several hundred. The predominant species include the mallard, black duck, common goldeneye, bufflehead, herring gull, and ring-billed gull. All winter species reported for Lake Michigan (Table 6) may occur here.

Muskegon

Open water in this harbor during the winter is restricted to small areas at the Consumer's Power Company power plant, the channel along the north shoreline and portions of the Muskegon River and nearby wastewater settling ponds. Waterbird use is primarily restricted to these open water areas. Regular car ferry traffic does periodically open a track near the entryway, but no bird use has been noted.

No site-specific studies of winter bird use of this harbor or adjacent Lake Michigan were found, but studies of bird life in marshes on the nearby portions of the Muskegon River have been made (Niegarth 1965). Species occurrence at this site is summarized in Table 12. The Muskegon Christmas Count area includes open water areas within the harbor and lakeshore, and count data are available for the last several decades (Appendix Table B16). Mid-winter surveys have regularly included this harbor. Wintering birds include canvasback, bufflehead, common goldeneye, common merganser, black duck, mallard, coot, herring gull and ring-billed gull. Total waterbird numbers in early winter run as high as 12,000 but are usually on the order of a few thousand. Predominant species are black duck, scaup spp., common goldeneye, common merganser, and herring gull. Mid-winter survey data indicate that a large number of mergansers use the Muskegon River in early January and probably continue to do so throughout the winter. Use of the nearby settling ponds is limited to early winter. In recent years several winter sightings of bald eagles have been made in the Muskegon area also (Lerg 1979). All winter species reported for Lake Michigan (Table 6) may occur here.

Ludington

No site-specific studies of winter bird use of this harbor and adjacent portions of Lake Michigan were found. The Ludington Christmas Count area includes portions of the harbor and Lake Michigan shoreline, and count data are available from 1965 to the present (Appendix Table B17).

The harbor is icebound the entire winter with the exception of a few small open patches and a track near the harbor mouth opened by car ferries. Waterbird use of the harbor is limited to the above areas, and includes small numbers of mallards, common goldeneye, bufflehead, common merganser, and herring gull. In addition Snowy owls are occasionally seen. All winter bird species recorded for Lake Michigan may occur here (Table 6).

Traverse City

No site-specific studies of winter bird use of the harbor and adjacent portions of Grand Traverse Bay were found, although studies of the mute swan populations have been reported (Gelston 1966, 1970, 1971, 1972). The Traverse City Christmas Count area includes portions of the bay and harbor and these data are available from 1960 to the present (Appendix Table B18).

Table 12. Winter Waterbirds in the Muskegon River Wetland.

Species	Winter	March	Arrival date
Pied-billed grebe	x		March 27
Great blue heron		x	March 30
Canada goose		x	March 16
Mallard		x	
Black duck		x	
Blue-winged teal		x	
Scaup spp.	x	x	
Common goldeneye	x	x	
Bufflehead	x	x	
Common merganser	x	x	
American coot		x	March 27
Herring gull	x	x	

Normally, the extreme lower portion of the bay freezes, but the mouth of the Boardman River and small areas along the shoreline remain open. The heaviest bird use occurs on the Boardman River. Several hundred mute swans and a few hundred mallards usually overwinter here and are dependent upon food supplied by local residents. Species present in early winter include the mallard, black duck, scaup spp., common goldeneye, bufflehead, herring gull, and ring-billed gull. The upper portions of the bay remain open most years, and all winter species typical of Lake Michigan (Table 6) may occur here.

Lake Huron

General information regarding winter bird use of Lake Huron comes from Michigan state bird books (Barrows 1912, Wood 1949), the Michigan Ornithological Society publication; the Jack-Pine Warbler; Christmas counts at Rogers City; Alpena, Saginaw; and mid-winter surveys. No site-specific studies were found. Most available data deals with near-shore and harbor areas. Information regarding the pelagic zone is sparse.

Winter bird use of Lake Huron is generally low, with one area of major concentration, Bay City. The location is a power plant site which attracts mergansers and mallards. Species which have been reported during the winter months are listed in Table 13. Common species are the mallard, common goldeneye, common merganser, and red-breasted merganser. These occur as scattered groups throughout open shoreline areas, although common mergansers do congregate at power plant sites and in the lower portions of rivers (e.g., Au Sable) during some winters (Salyer and Lagler 1940). Bellrose (1980) estimates that 500 common goldeneyes winter on Lake Huron. Bald eagles are occasionally sighted along shoreline areas also.

Calcite Harbor

No site-specific studies of winter bird use of this harbor or adjacent Lake Huron were found. Waterbirds and gulls occasionally use open water areas near the harbor. All winter species recorded for Lake Huron may occur in the area (Table 13). The Rogers City Christmas Count area is located nearby, and count data are probably representative of early winter birds in this area. These data are available from 1973 to the present and are summarized in Appendix Table B19. Total waterbird numbers as high as 1800 have been recorded, but the majority of these are herring gulls. Other species, represented by as many as 100 individuals, include the common goldeneye, hooded merganser, and common merganser. Occasionally snowy owls are sighted.

Alpena and Thunder Bay

No site-specific studies of winter bird use of this harbor or adjacent portions of Thunder Bay were found. Much of Thunder Bay is icebound throughout the winter months, and the only open water near or in the harbor is at the mouth of the Thunder Bay River and portions of the river below dam sites. Waterbird use of this area is restricted to the above areas.

Christmas Count data for the Alpena area are available from 1960 to the present (Appendix Table B20). Total waterbird populations have ranged from about 100 to 1200 birds. The most abundant waterfowl include Canada goose,

Table 13. Winter[a] Bird Species of U. S. Lake Huron.

Common name	Winter status[b]	Abundance[c]
PODICIPEDIDAE		
Pied-billed grebe	Accidental-permanent	Rare
Horned grebe	Casual-visitant	Rare
ANATIDAE		
Canada goose	Regular-visitant	Locally uncommon
Mallard	Regular-permanent	Common
Black duck	Regular-permanent	Uncommon
Gadwall	Casual-permanent	Rare
Pintail	Casual-permanent	
Redhead	Regular-visitant	Uncommon
Canvasback	Regular-visitant	Uncommon
Common goldeneye	Regular-permanent	Common
Scaup spp.	Casual-visitant	Uncommon
Bufflehead	Regular-visitant	Rare
Oldsquaw	Regular-visitant	Uncommon
Common merganser	Regular-permanent	Common to locally abundant
Red-breasted merganser	Regular-permanent	Common
ACCIPITRIDAE		
Goshawk	Casual-permanent	Rare
Red-tailed hawk	Casual-permanent	Rare
Rough-legged hawk	Casual-visitant	Rare
Bald eagle	Regular-permanent	Rare

Table 13 (concluded).

Common name	Winter status[b]	Abundance[c]
LARIDAE		
Great black-backed gull	Casual-visitant	Rare
Herring gull	Regular-permanent	Locally abundant
Ring-billed gull	Casual-permanent	Uncommon
Bonaparte's gull	Accidental-visitant	Rare
STRIGIDAE		
Great horned owl	Regular-permanent	Rare
Snowy owl	Regular-visitant	Locally uncommon

[a]Taken from available historical records.
[b]Accidental - occurs rarely, casual - occurs some years, regular - seen almost all years; visitant - not present as breeding bird, straggler - late migrant; permanent - some individuals (*though not necessarily* the same) present year-round.
[c]Rare - <10 per observer day, uncommon - 10-100; common- 100-1000; abundant >1000.

mallard, common goldeneye, common merganser, and herring gull. Snowy owls and bald eagles are occasionally sighted also.

Bay City and Saginaw Bay

No site-specific information on winter bird use of this area was found. It is regularly included in the mid-winter survey, and Christmas count data are available from 1949 to the present. Count data from the last 20 years are summarized in Appendix Table B21.

Saginaw Bay is icebound throughout the winter, and the only open water is at the outflow from the J. C. Weadock power plant. Total waterbird populations in early January have ranged from a few hundred to over 6000 birds, and can include large numbers of common mergansers, herring gulls, and ring-billed gulls. Several hundred mallards and black ducks can be found here also. Occasionally snowy owls and bald eagles are sited.

Detroit-St. Clair System

Several studies concerning winter bird use of this area have been made (Miller 1948, Hunt 1957, 1961, 1965, Hunt and Cowan 1963, Kelley 1978). In addition, this area has been included in the continental mid-winter Survey since 1949. Two Christmas counts are included in this area, the Detroit River count and the Anchor Bay count. Count data are summarized in Appendix Tables B22 and B23.

This area includes the St. Clair River, Lake St. Clair, and Detroit River and is well-known for its large winter waterfowl concentrations. A total winter population on the order of 40,000 birds is not unusual, and it has been as high as 140,000 (Michigan DNR files). The winter species of this area are presented in Table 14. The predominant species are redhead, canvasback and common goldeneye. In some years scaup are abundant. Attesting to the importance of this area is the fact that the canvasback population has represented as much as 13.3% of the total U. S. winter population (Martz 1976). Other species present in unusual numbers include swan spp. and the Canada goose.

The sites most used in this system include the St. Clair Flats and the Lower Detroit River, especially Celeron, Horse, and Grassy Island. During maximum ice cover, most of the birds congregate at or near Celeron Island.

Table 14. Winter[a] Species of the Detroit-St. Clair System.

Common name	Winter status[b]	Abundance[c]
ANATIDAE		
Swans	Regular-visitant	Uncommon
Canada goose	Regular-visitant	Common
Mallard	Regular-permanent	Common
Black duck	Regular-visitant	Common
Gadwall	Casual-visitant	Rare
American wigeon	Regular-visitant	Uncommon
Redhead	Regular-visitant	Abundant
Canvasback	Regular-visitant	Abundant
Scaup spp.	Regular-visitant	Common to abundant
Common goldeneye	Regular-visitant	Abundant
Bufflehead	Regular-visitant	Uncommon
Oldsquaw	Casual-visitant	Rare
Wood duck	Accidental-visitant	Rare
Ruddy duck	Accidental-visitant	Rare
Common merganser	Regular-visitant	Common
Red-breasted merganser	Regular-visitant	Rare
ACCIPITRIDAE		
Bald eagle	Casual-visitant	Rare
LARIDAE		
Great black-backed gull	Casual-visitant	Rare
Herring gull	Regular-visitant	Common
Ring-billed gull	Regular-visitant	Uncommon

Table 14 (concluded).

Common name	Winter status[b]	Abundance[c]
Bonaparte's gull	Casual-visitant	Rare
Black-legged kittiwake	Accidental-visitant	Rare
ARDEIDAE		
Great blue heron	Casual-visitant	Rare
STRIGIDAE		
Snowy owl	Casual-visitant	Rare

[a]Taken from available historical data.
[b]Accidental - occurs rarely, casual- occurs some years, regular - seen almost all years; visitant - not present as breeding bird, straggler - late migrant; permanent - some individuals (though not necessarily the same) present year-round.
[c]Rare - <10 per observer day, uncommon - 10-100, common 100-1000; abundant >1000.

Aerial Surveys

Methods. Eight aerial surveys of bird distribution on the U. S. Upper Great Lakes were conducted during the winters of 1979-80 and 1980-81. The species included were primarily waterbirds (See Table 2). The surveys were made at approximately two-week intervals during January, February, and March of each year and thus included the time period during which interlake shipping is minimal due to non-operation by COE locks. The closing and opening dates of the locks on the St. Mary's River ended on 31 December, 1979 and 15 January 1981, and opened on 24 March of both years. These represent a two and four week extension beyond the traditional closing date (15 December).

All survey flights were made with a fixed-wing aircraft (Cessna Skymaster) flown at low altitude and the pilot and one additional observer recording bird sightings. A complete survey took approximately three consecutive days (20 hours of actual flight time) to complete. The survey encompassed about 1200 km of shoreline including most major harbors and connecting channels on the upper three Great Lakes (Table 15, Figure 1). Nearly all harbors involved in winter navigation were surveyed regularly. In addition, selected power plant sites and other areas of known or suspected high bird use were surveyed. Weather conditions often precluded flights. Most notable areas were the south shore of Lake Superior and the east shore of Lake Michigan. Canadian shores and harbors were not included in the study. Shorelines were surveyed at altitudes of 200m or less at distances of 1/2 to 1 km from shore. Bird sightings were recorded by species and number using U. S. Geological Survey topographic maps (1:250,000) to locate them as precisely as possible.

Large bird concentrations were examined at lower altitudes (100-200m) and, in some cases, were photographed to assess the accuracy of the aerial estimates. A hand-held 35 mm camera with normal (55 mm) lens and color slide film were used for this purpose. Harbors and other areas of particular interest (e.g., power plants) were also surveyed at low altitude, and sightings were recorded on detail maps by the U. S. Army Corps of Engineers. Ice cover in harbors and general shoreline conditions were mapped. The data were supplemented with information derived from NOAA Great Lakes ice charts. These charts represent a synthesis of ice cover data obtained from satellite imagery, aerial reconnaissance, side-looking airborn radar (SLAR), and various surface ice reports (Quinn et al. 1978).

Methodologies used in the aerial surveys had several limitations. Most importantly, there was little control over the time of day various areas were flown. Several local observers reported that winter birds in their areas migrate between resting and feeding areas on a daily basis. Some further noted that some sites, e.g., power plants, were used only at dawn and dusk. The survey data represent only one point in time at each site and may not be representative of overall usage of various areas.

The survey data are biased by various factors associated with species visibility. This is most evident with respect to pelagic species such as oldsquaw, which use areas up to several miles offshore and were probably underestimated. Some species such as those with contrasting colors (e.g., the black and white of mergansers and goldeneyes) are more visible from the

Table 15. Harbors, Connecting Channels, and other Sites Surveyed for Bird Use During the Winters of 1979-80 and 1980-81.

Site	Proposed winter shipping site[a]	Potential impact[b]	Recommended for study[b]	Number of times surveyed
Lake Superior				
Grand Marais	no	no	no	4
Taconite Harbor	yes	no	no	4
Silver Bay	yes	no	no	4
Two Harbors	yes	no	no	4
Duluth-Superior	yes	no	no	8
Ashland	yes	??	no	5
Marquette	yes	no	yes	6
Presque Isle	yes	no	yes	6
Lake Michigan				
Escanaba	yes	no	no	2
Green Bay & Fox River	yes	yes	yes	4
Kewaunee Power Plant	no	no	no	6
Manitowoc	no	no	no	6
Port Washington	yes	??	yes	6
Milwaukee	yes	??	no	6
Racine	no	no	no	7
Kenosha	no	no	no	7
Calumet	yes	no	no	6
Indiana Harbor	yes	no	no	6
Gary	yes	no	no	6
Burns Waterway	yes	no	no	6
Muskegon	yes	no	no	6
Ludington	yes	no	no	5
Traverse City	yes	yes	no	2
St. Mary's River	yes	yes	yes	3

Table 15 (Concluded).

Site	Proposed winter shipping site[a]	Potential impact[b]	Recommended for study[b]	Number of times surveyed
Lake Huron				
Alpena	yes	??	yes	4
Bay City	yes	no	no	7
Detroit-St. Clair System	yes	yes	yes	8
Monroe Power Plant (1981 only)	no	no	no	4

[a] Included in Corps of Engineers Survey Study (1979).
[b] As indicated in U. S. Fish and Wildlife Service Report (1979) to accompany Corps of Engineers Survey Report, Great Lakes Navigation Season Extension (1979).

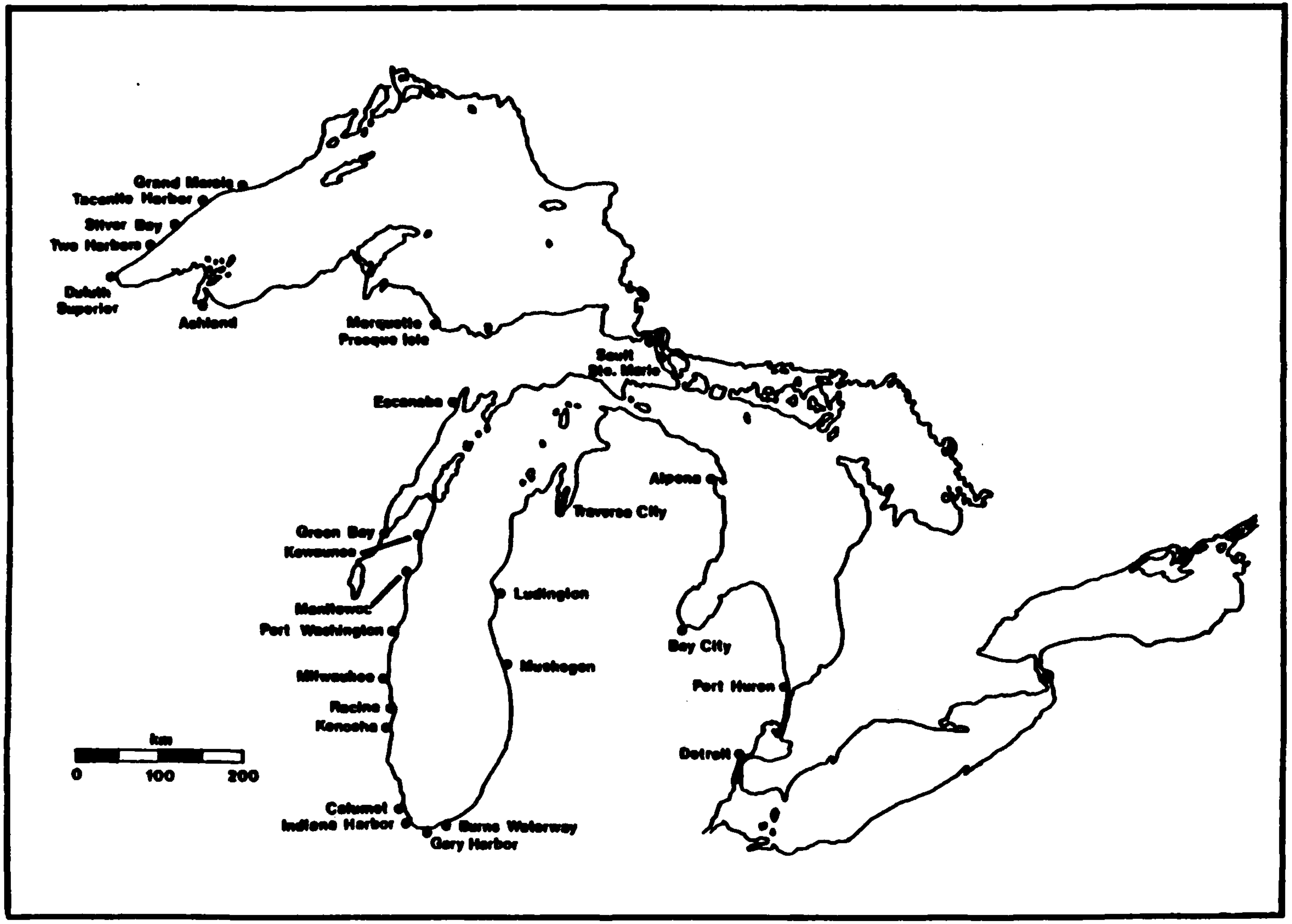


Figure 1. Harbors included in aerial surveys, winters of 1979-80 and 1980-81.

air. These and other limitations of aerial survey data have been outlined previously (Cook and Jacobson 1979).

Results. With respect to ice conditions and weather, the winters of 1979-80 and 1980-81 were termed "normal" for the Great Lakes by the National Weather Service and the U.S. Coast Guard Ice Navigation Center. This assessment is based on overall ice conditions and cumulative freezing degree-day data for the entire winter season.

While both years fell within the norm, 1979-80 was unusually mild during November, December, and January. This was reflected in the relative lack of ice in some areas. A comparison of ice cover patterns with normal patterns (Rondy 1971) indicates that ice development was delayed two weeks on the Upper Great Lakes that year. The remainder of the winter was characterized by low snowfall and a lack of major storms. Temperatures were not extreme as no long cold periods or thaws were reported for most of the area.

The early winter of 1980-81 was also mild, but extreme cold occurred by early January. As in 1979-80, snowfall was below average. Spring came early in most of the area as a quick thaw occurred in late February.

The accuracy of counts of large waterbird congregations was assessed using aerial photography as already noted. Ten large groups were tested and no count bias, with respect to size was apparent (Table 16).

In general, the species and numbers of birds encountered, as well as the areas utilized by them, were within the range expected based upon historic usage patterns. A total of 24 "waterbird" species were observed, including three species of gull, 17 waterfowl, and one heron (Table 17). Two species of raptor were also seen.

The predominant waterfowl, in descending order of abundance, were canvasback, redhead, scaup spp., oldsquaw, mallard, common merganser, and common goldeneye (Figure 2). Large numbers of gulls, consisting of ring-billed and herring, were observed on occasion also. A summary of the number of birds seen by species and lake region (e.g., south shore of Lake Superior) for each survey is given in Appendix C.

Seasonal patterns in waterfowl and gull abundance were difficult to assess since most species were found in large concentrations. Thus, omission of one or more sites due to weather or other factors greatly affected species abundance as indicated by the survey totals. This is further complicated by the fact that, as previously mentioned, some flocks were quite mobile and in some instances had definite diurnal migratory patterns. Thus, the survey totals can be misleading. Nonetheless, the totals for the dominant species are given in Figure 2.

Because of the mildness of the late fall and early winter of 1979-80, many birds apparently remained in the lakes area longer than normal. This was most apparent in the high number of redheads and canvasbacks which remained in the Detroit-St. Clair System well into January. The mid-winter (early January) count for both species was exceptionally high, although by

Table 16. Comparison of Aerial and Photo Estimates of Bird Concentrations.

Group	Aerial estimate	Photo count	% error[a]
1	650	845	- 30.0
2	200	179	+ 10.7
3	450	575	- 27.8
4	2300	1658	+ 27.9
5	400	452	- 13.0
6	700	591	+ 15.5
7	300	325	- 8.4
8	200	175	+ 12.3
9	750	879	- 17.2
10	350	421	- 20.4
Mean			18.3 ± 7.9[b]

[a]Using photo count as accurate numbers.
[b]Mean of absolute values of % error ± standard deviation.

Table 17. Species Recorded During Aerial Surveys of the Upper Great Lakes, Winters of 1979-80 and 1980-81.

Common Name	Scientific Name
Double-crested cormorant	Phalacrocorax auritus
Great blue heron	Ardea herodias
Whistling swan	Olor columbianus
Mute swan	Cygnus olor
Canada goose	Branta canadensis
Mallard	Anas platyrhynchos
Black duck	Anas rubripes
Gadwall	Anas strepera
American wigeon	Anas americana
Redhead	Aythya americana
Canvasback	Aythya valiserina
Greater scaup	Aythya marila
Lesser scaup	Aythya affinis
Common goldeneye	Bucephala clangula
Bufflehead	Bucephala albeola
Oldsquaw	Clangula hyemalis
Black scoter	Melanitta perspicillata
Common merganser	Mergus merganser
Red-breasted merganser	Mergus serrator
Bald eagle	Haliaetus leucocephalus
Herring gull	Larus argentatus
Ring-billed gull	Larus delawarensis
Great black-backed gull	Larus marinus
Snowy Owl	Nyctea scandiaca

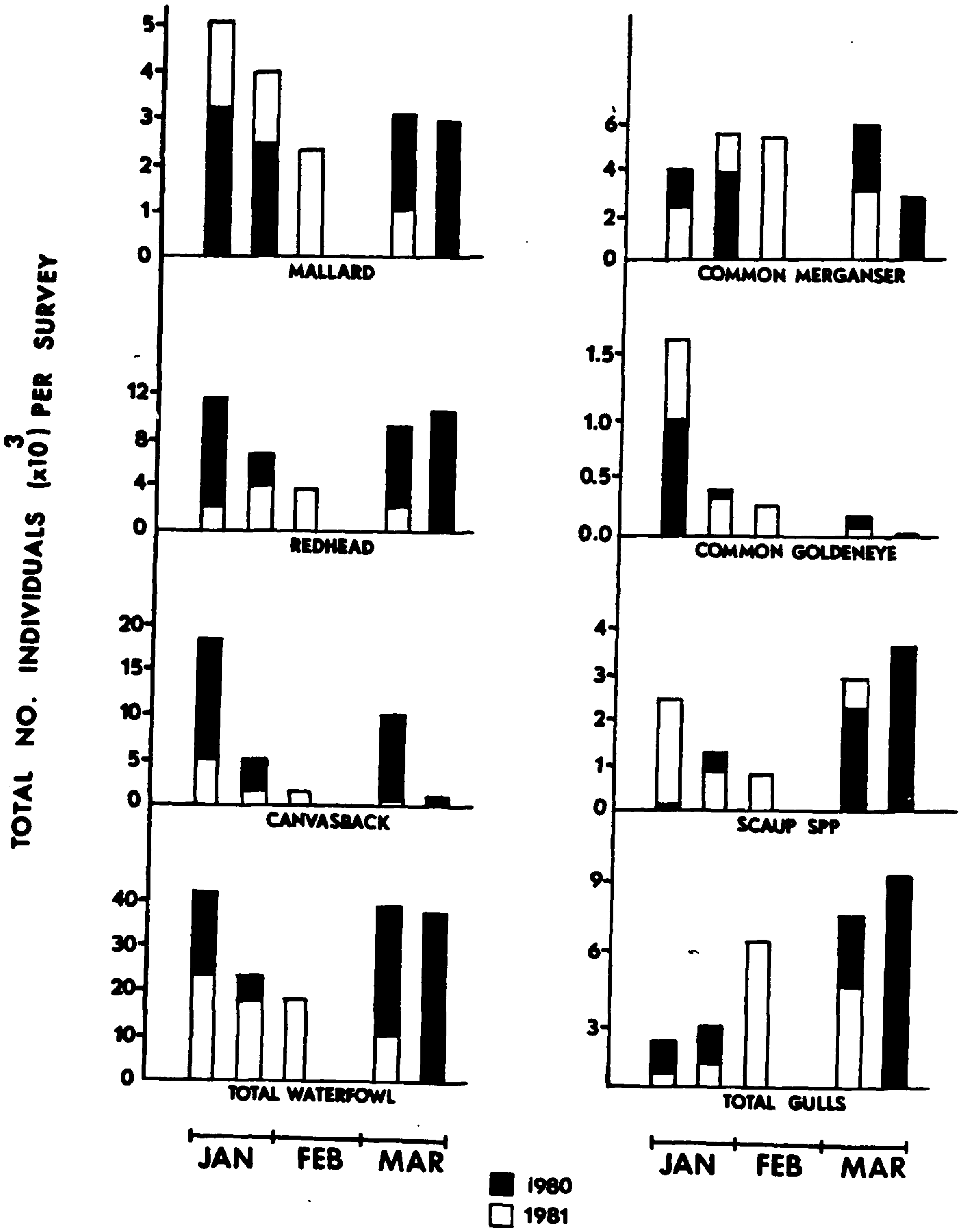


Figure 2. Summary of aerial surveys, 1980-81, for the upper Great Lakes.

late January the populations had diminished appreciably. This would indicate that many of these birds continued their migration to the east coast. An unusually low January count for these species at Chesapeake Bay supports this hypothesis. Unfortunately, late winter surveys were not made at Chesapeake Bay, and thus it is not known whether numbers increased there as birds left the Detroit area. Additional evidence for a delayed fall migration during 1979-80 comes from general observations reported in state ornithological journals for Minnesota, Michigan, and Wisconsin. Migratory movements in National Wildlife Refuges in the study area were also delayed.

In contrast, more "normal" waterbird populations were seen during the 1980-81 winter. Early January totals for both gulls and waterfowl were far lower than in 1979-80. The large number of gulls seen in late February probably reflects the early return of migrants due to the unusually warm weather and subsequent February early thaw. It appears the major waterfowl migration occurred in late February avoiding the March aerial surveys which resulted in the low survey totals observed in early March .

Total waterfowl numbers per survey varied widely (from 10,000 to 40,000), but true winter populations, omitting surveys which probably included early or late migrants, appear to be near 20,000 both years. This figure represents only a fraction of the actual wintering population on the upper lakes, but should be a first-order approximation of near-shore and harbor use.

Gull populations were quite variable, but did show a general increase from early winter to spring (Figure 2). This probably reflects the migratory behavior of gulls which migrate to the Lower Great Lakes during the early winter and gradually return to breeding areas by mid to late March (Southern 1974). For the most part, gull concentrations of a few hundred birds occured in harbors and around power plants. Survey totals for near shore areas were approximately a few thousand birds. Although species identification was usually not attempted from the air, predominant species were herring and ring-billed gulls. The only other gull species positively identified was the great black-backed gull.

Areas within the Upper Great Lakes which had major winter waterbird concentrations were limited (Figures 3 and 4). The major waterfowl areas were the lower Detroit River, the lower St. Clair River and adjacent areas of Lake St. Clair, the J. C. Weadock Power Plant at Bay City, Michigan, Milwaukee harbor, and the Bay Beach Wildlife Sanctuary and associated Fox River at Green Bay, Wisconsin. Other areas of moderate bird use were Port Washington harbor, Racine, the Saint Mary's River, Muskegon, and Traverse City.

Major gull concentrations were found at many of the same sites as were used by waterfowl. Included are the Detroit-St. Clair System, Milwaukee, and Muskegon. Moderate numbers were seen at Marquette also. Thus it is apparent that the areas most heavily used overall (by both waterfowl and gulls) were the Detroit-St. Clair System, Milwaukee, and Muskegon.

The actual numbers using these sites were quite variable, reflecting changing ice conditions, etc., and thus these data are not amenable to statistical analyses. However, the same sites were used both years.

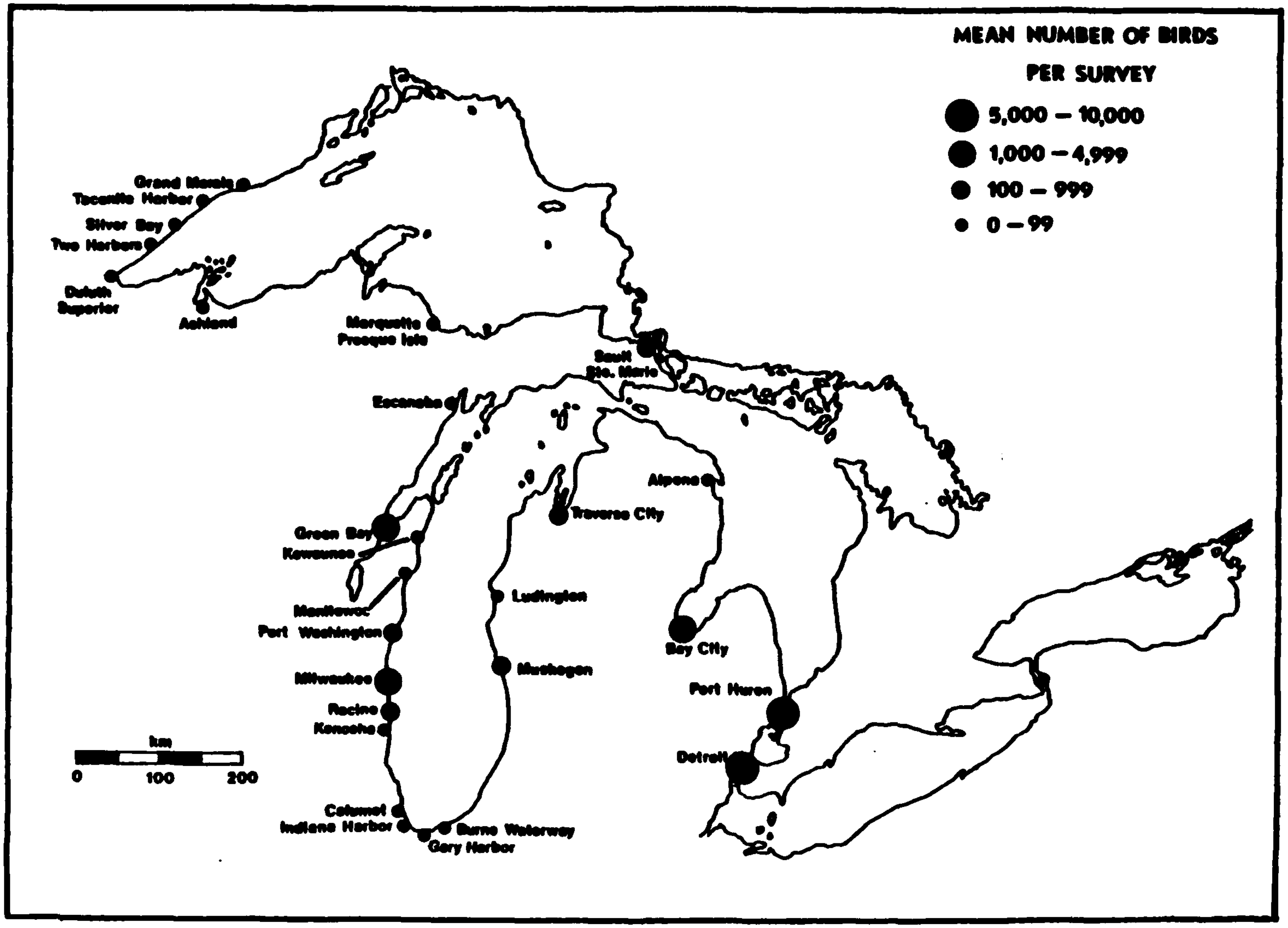


Figure 3. Mean number of waterfowl per aerial survey (N=3-8) for harbors and connecting channels in the Upper Great Lakes, winter of 1979-80 and 1980-81.

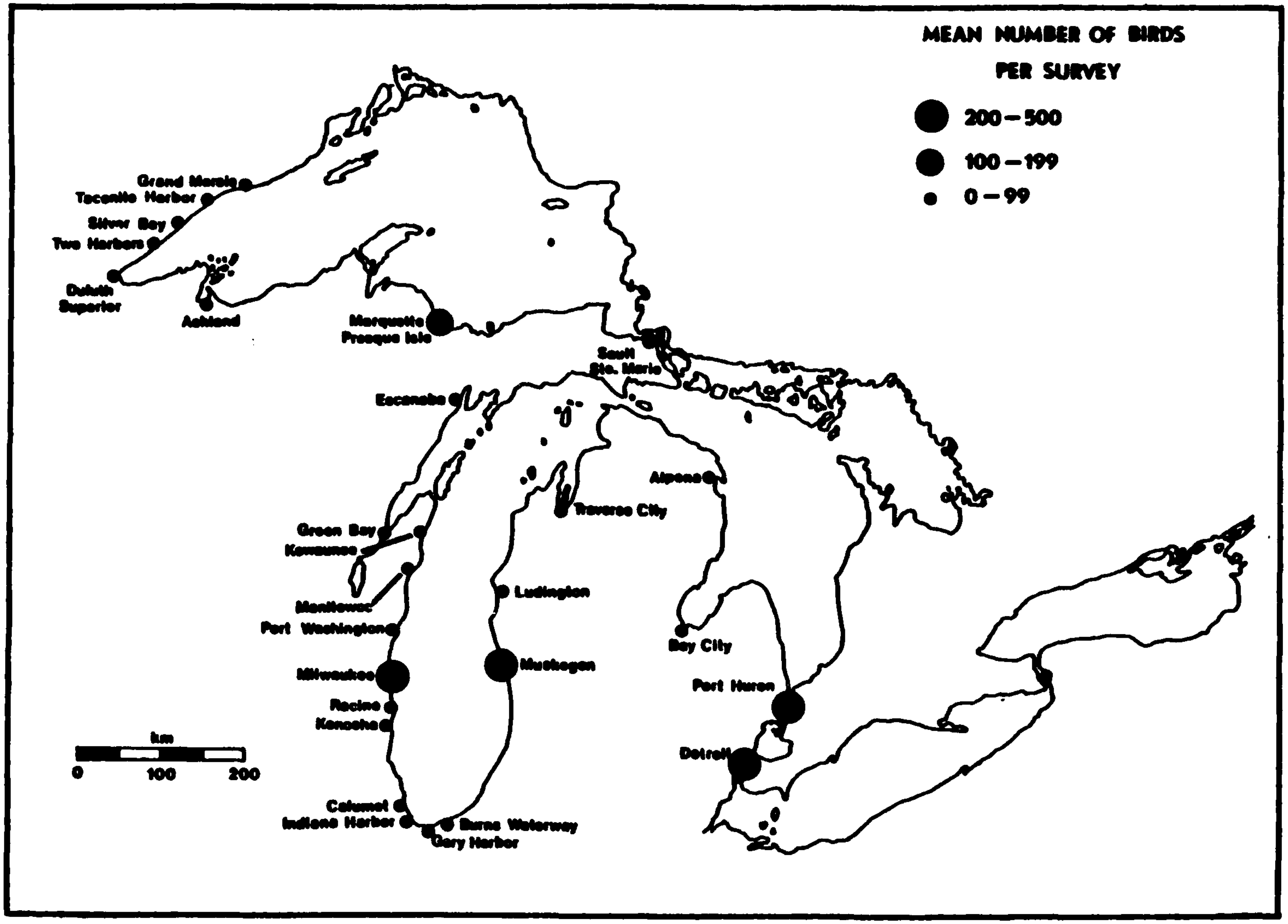


Figure 4. Mean number of gulls per aerial survey (N=3-8) for harbors and connecting channels in the Upper Great Lakes, winters of 1979-80 and 1980-81.

Use of nearshore areas, excluding major concentration sites, is depicted in Figures 5-20. These maps present the numbers of birds seen per km for each major lake region (Table 18) for each survey. Areas with no stippling were not censused.

With the exception of those surveys conducted during migratory movements, both gulls and waterfowl were present in low numbers in offshore waters (< 1.0 birds/km). Shoreline use did increase dramatically during the migratory season each year (late February 1981 and mid March 1980). The high concentration of gulls during late March 1980 reflects the presence of breeding birds.

A Chi-square test for a relationship between bird density over large sections of shoreline and percentage ice cover was run, and yielded different results for gulls and waterfowl. To test this relationship, all major shoreline regions (Table 18) were classified by major ice cover categories (0-33%, 34-66%, and 67-99%) and bird density (Figures 5-20) for each survey. Each region was treated as a data point, and 27 such points were tested. The null hypothesis was that ice cover (less than 100%) did not affect bird density.

On this basis, no significant relationship between waterfowl density and ice cover could be established ($x^2 = 7.5$, $\underline{p} = 0.14$, $n = 4$). However, gull density showed a highly significant relationship with ice cover ($x^2 = 19.9$, $\underline{p} < 0.001$, $n = 4$). It appears that gull densities were far higher in areas of little ice (0-33%) (Table 19). It should be noted that this may reflect only the fact that the larger gull populations were evident primarily during the spring migration season and thus at a time when open water was more abundant. Whether a causal relationship exists is therefore not clear. The apparent lack of effect on waterfowl densities seems to indicate that bird use requires only small amounts of open water. However, it should be noted that a higher percentage of ice concentrates birds in smaller areas, and thus these birds were more likely to be seen during census flights than small scattered groups. This may have artifically elevated numbers recorded in in these areas.

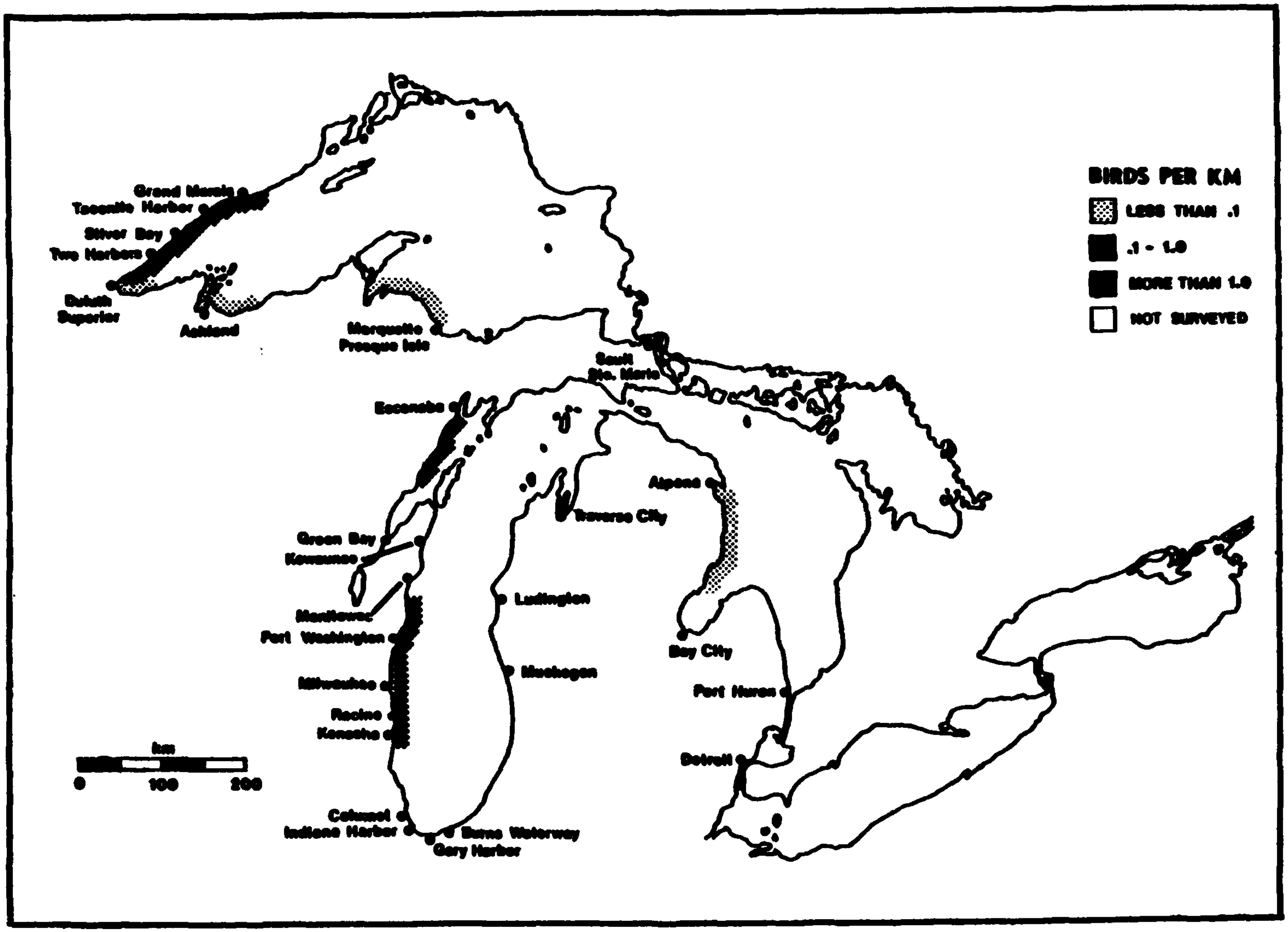
Table 18. Major Lake Regions Used for Summaries of Shoreline Use by Waterbirds.

Region	Description
Lake Superior	
North Shore	Minnesota Shore
South Shore	Wisconsin and Michigan Shores
Lake Michigan	
West Shore	Wisconsin Shore excluding Green Bay
South Shore	Illinois and Indiana Shores
East Shore	Michigan Shore
Lake Huron	All U. S. Shore

Table 19. Gull Density in Birds/km as a Function of Ice Cover.

	% Ice Cover[a]			
Birds/km	0-33	34-66	67-99[b]	Total
0-0.1	22[b]	0	75	97
>.1-1.0	30	4	4	38
>1.0	11	0	4	15
Total	63	4	83	100

[a]Percentage of all occurrences in each category (n=27), each occurrence implies known bird density and ice cover for a major lake region (e.g., South Shore Lake Superior) for a given aerial survey.
[b]Areas of 100% ice cover not surveyed and thus not included in data.



• Figure 5. Number of waterfowl per km of shoreline for major lake regions (see Table 17) seen on aerial survey, early January, 1980.

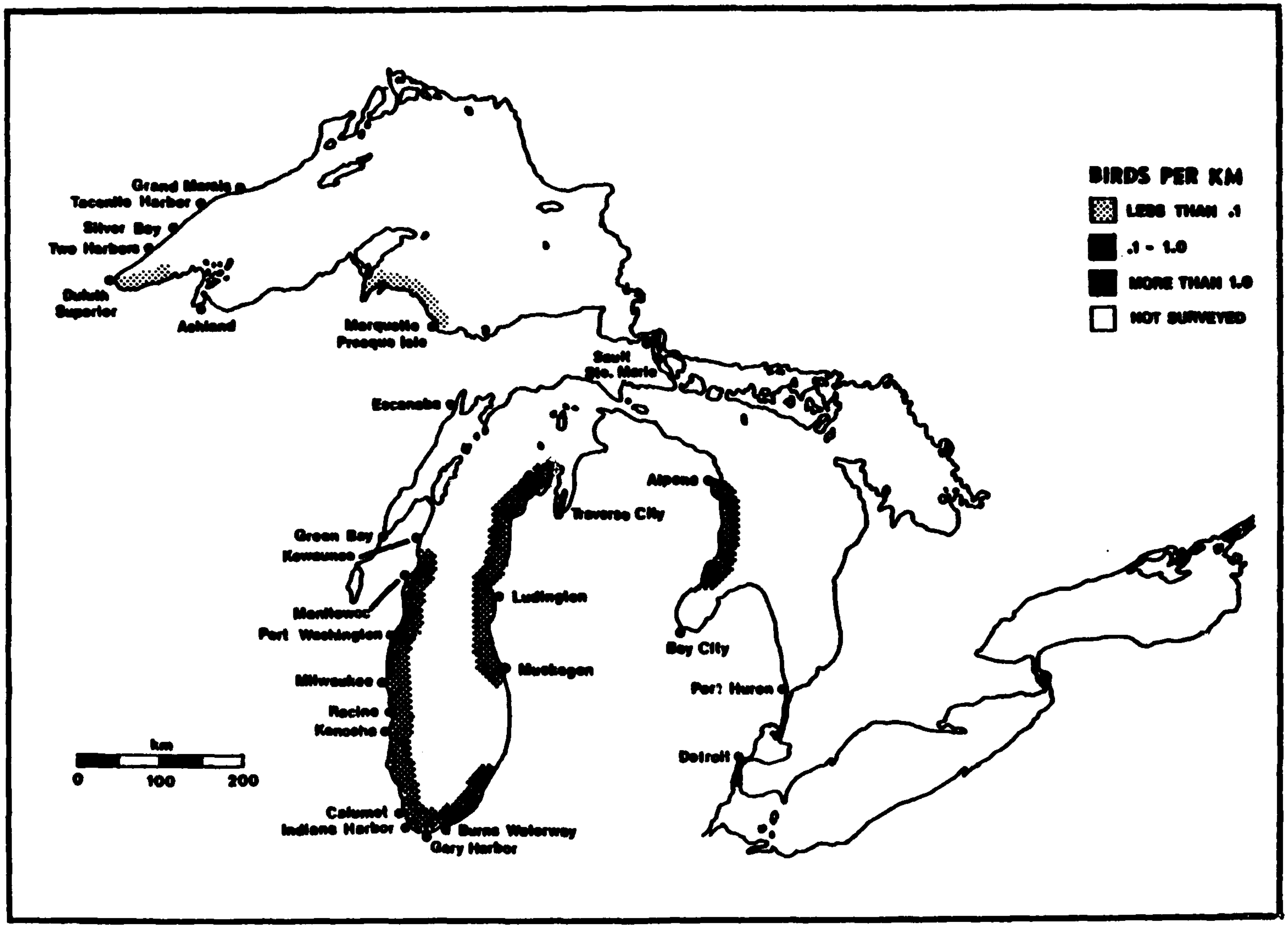


Figure 6. Number of waterfowl per km of shoreline for major lake regions (see Table 17) seen on aerial survey, late January, 1980.

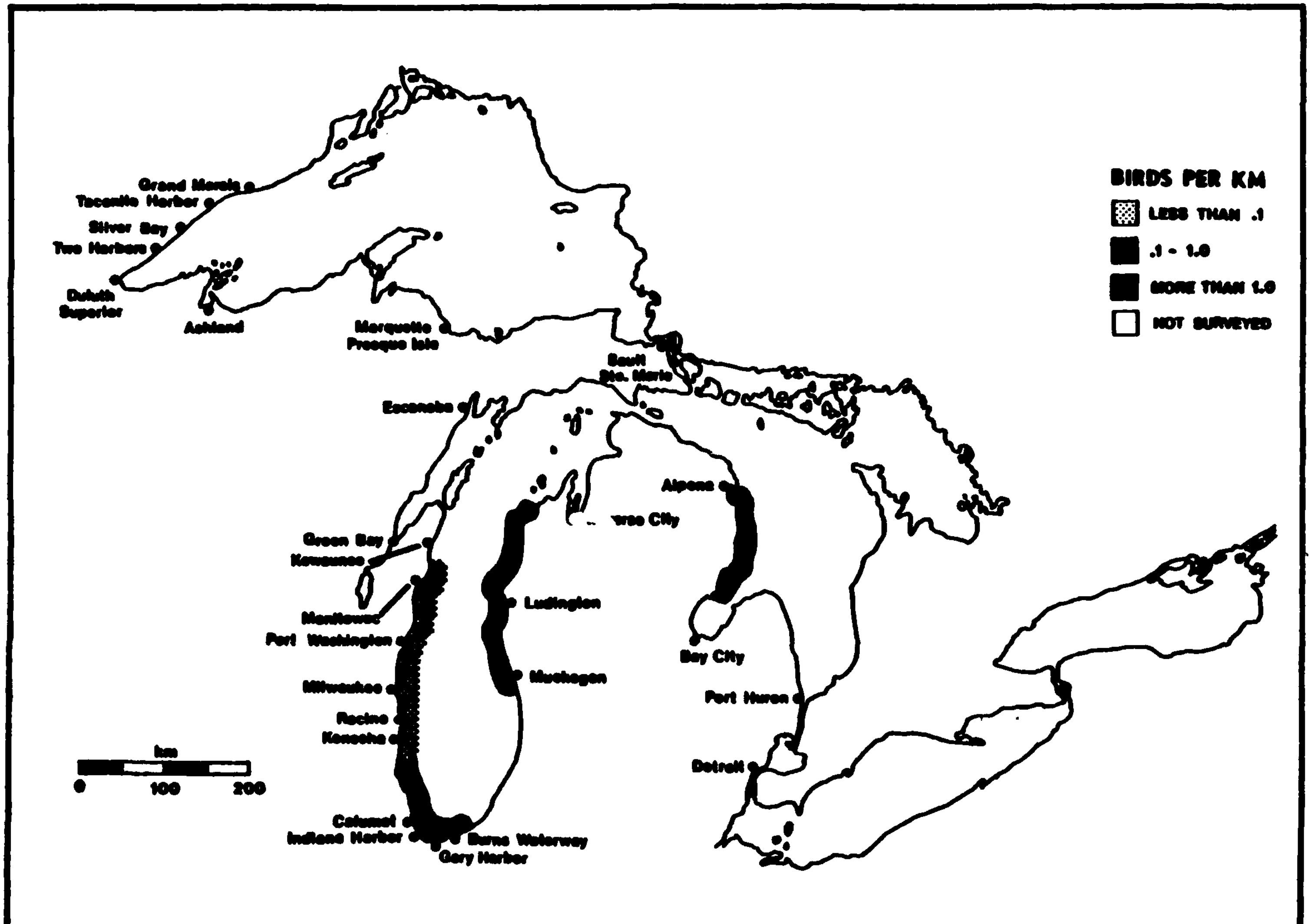


Figure 7. Number of waterfowl per km of shoreline for major lake regions (see Table 17) seen on aerial survey, early March, 198[illegible].

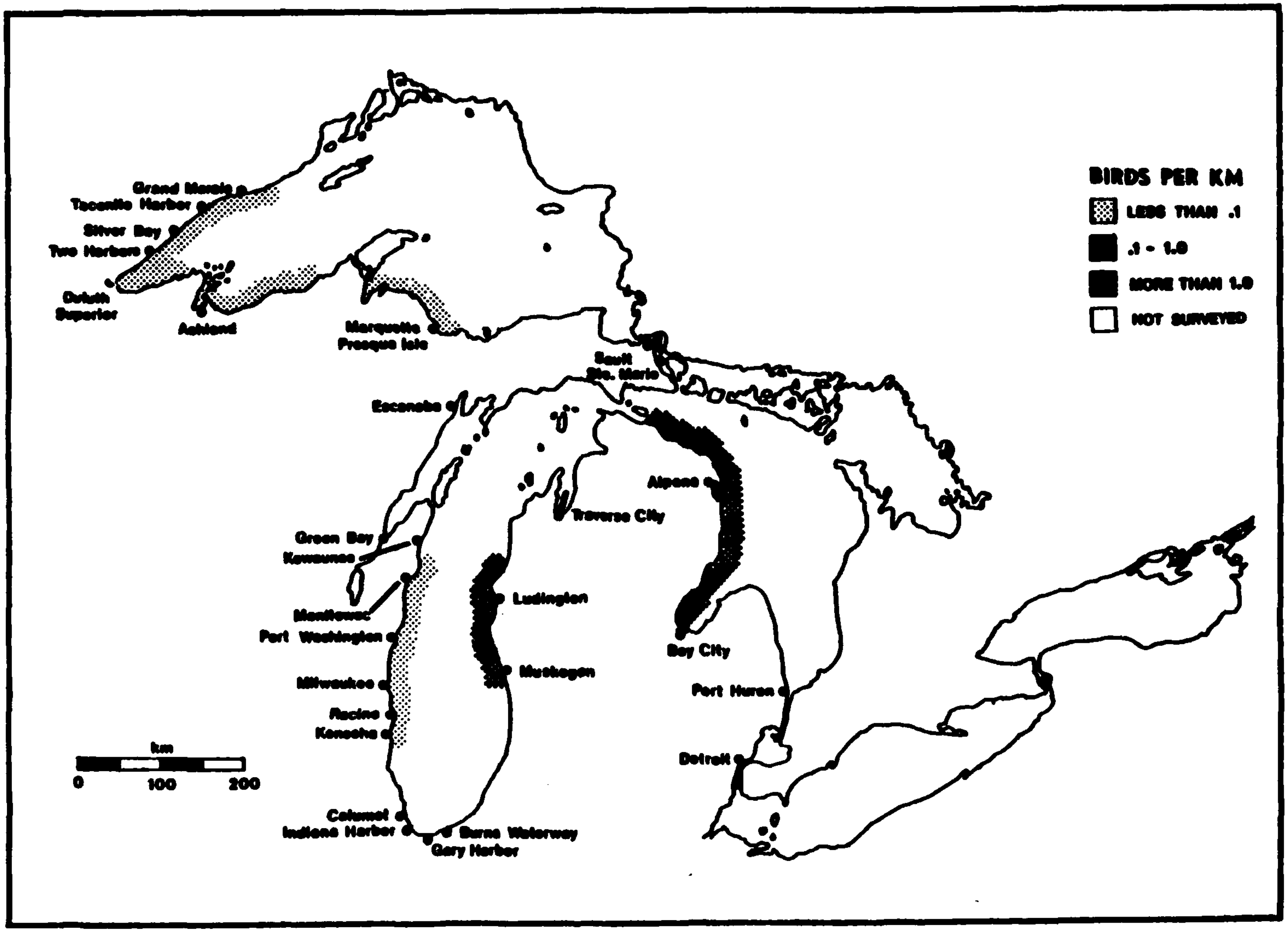


Figure 8. Number of waterfowl per km of shoreline for major lake regions (see Table 17) seen on aerial survey, late March, 1980.

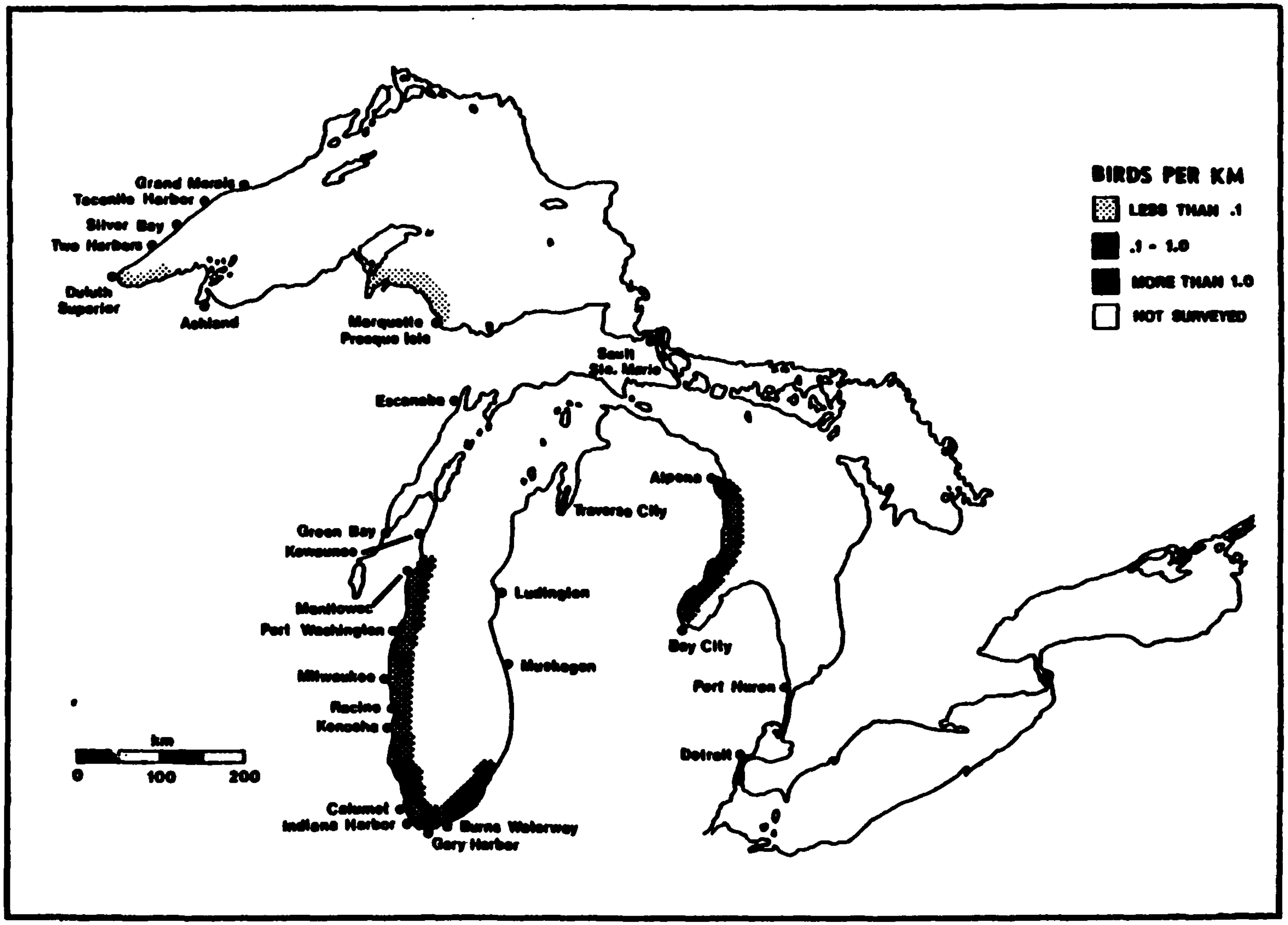


Figure 9. Number of waterfowl per km of shoreline for major lake regions (see Table 17) seen on aerial survey, early January, 1981

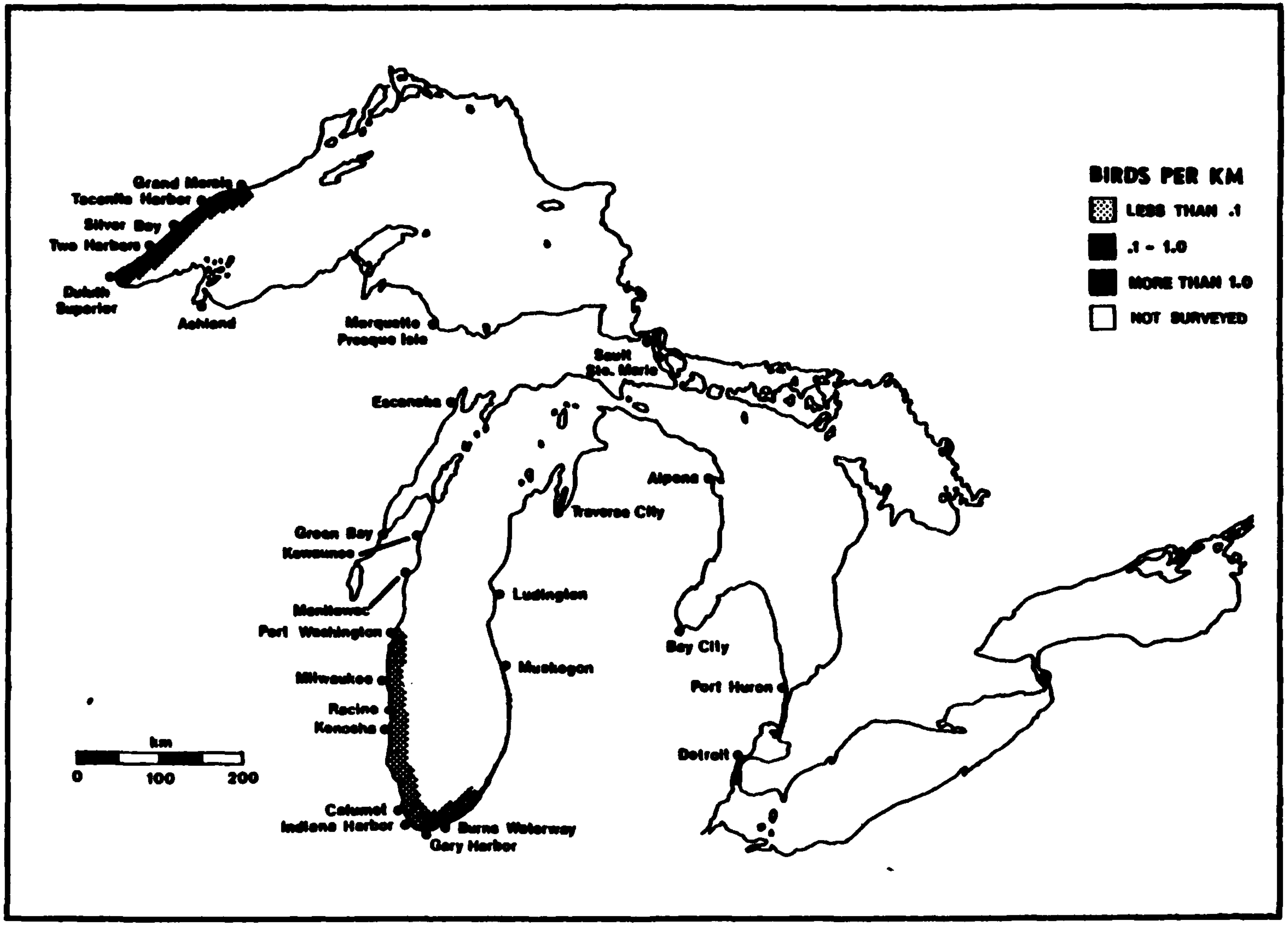


Figure 10. Number of waterfowl per km of shoreline for major lake regions (see Table 17) seen on aerial survey, late January,1981.

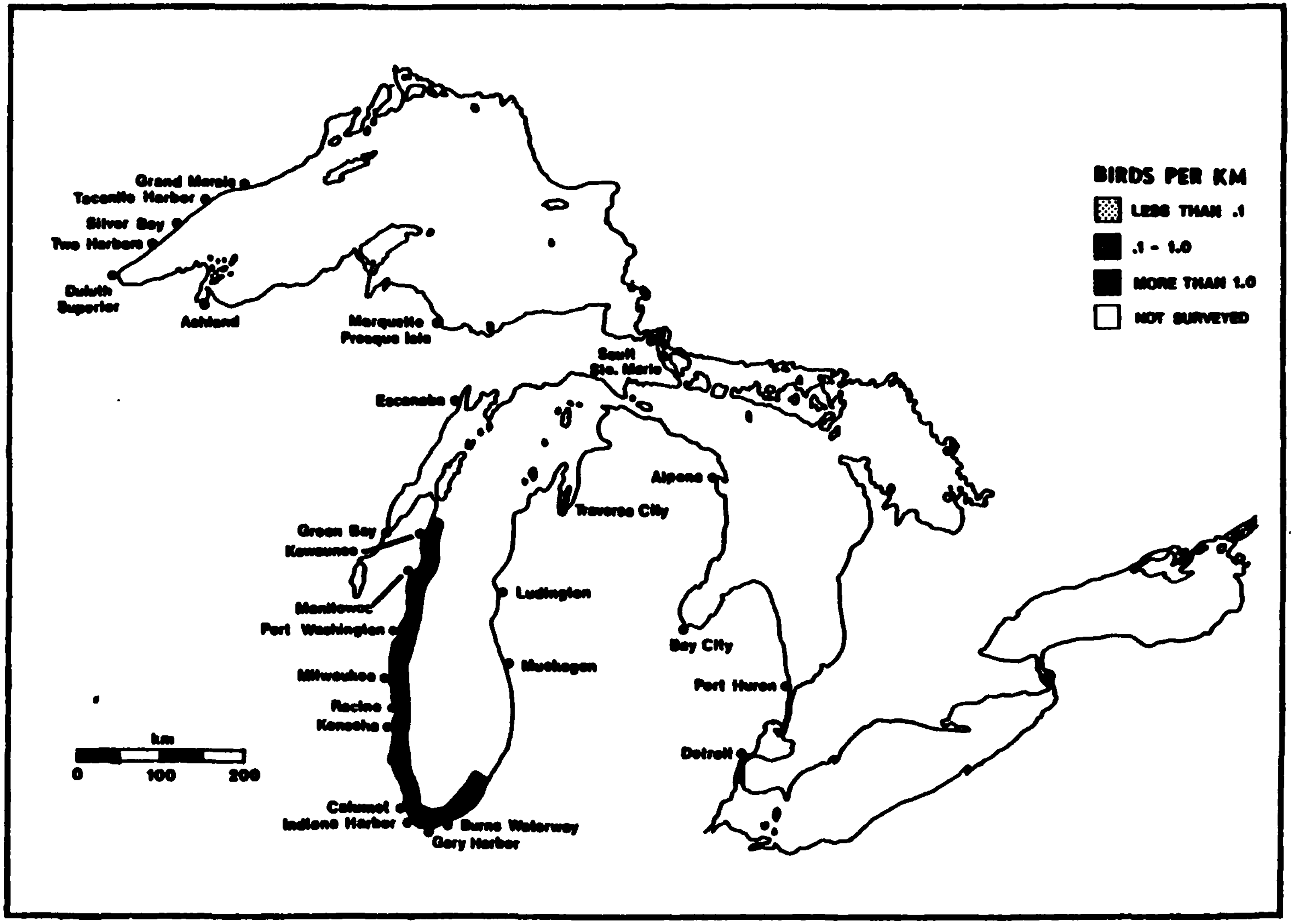


Figure 11. Number of waterfowl per km of shoreline for major lake regions (see Table 17) seen on aerial survey, early February, 1981.

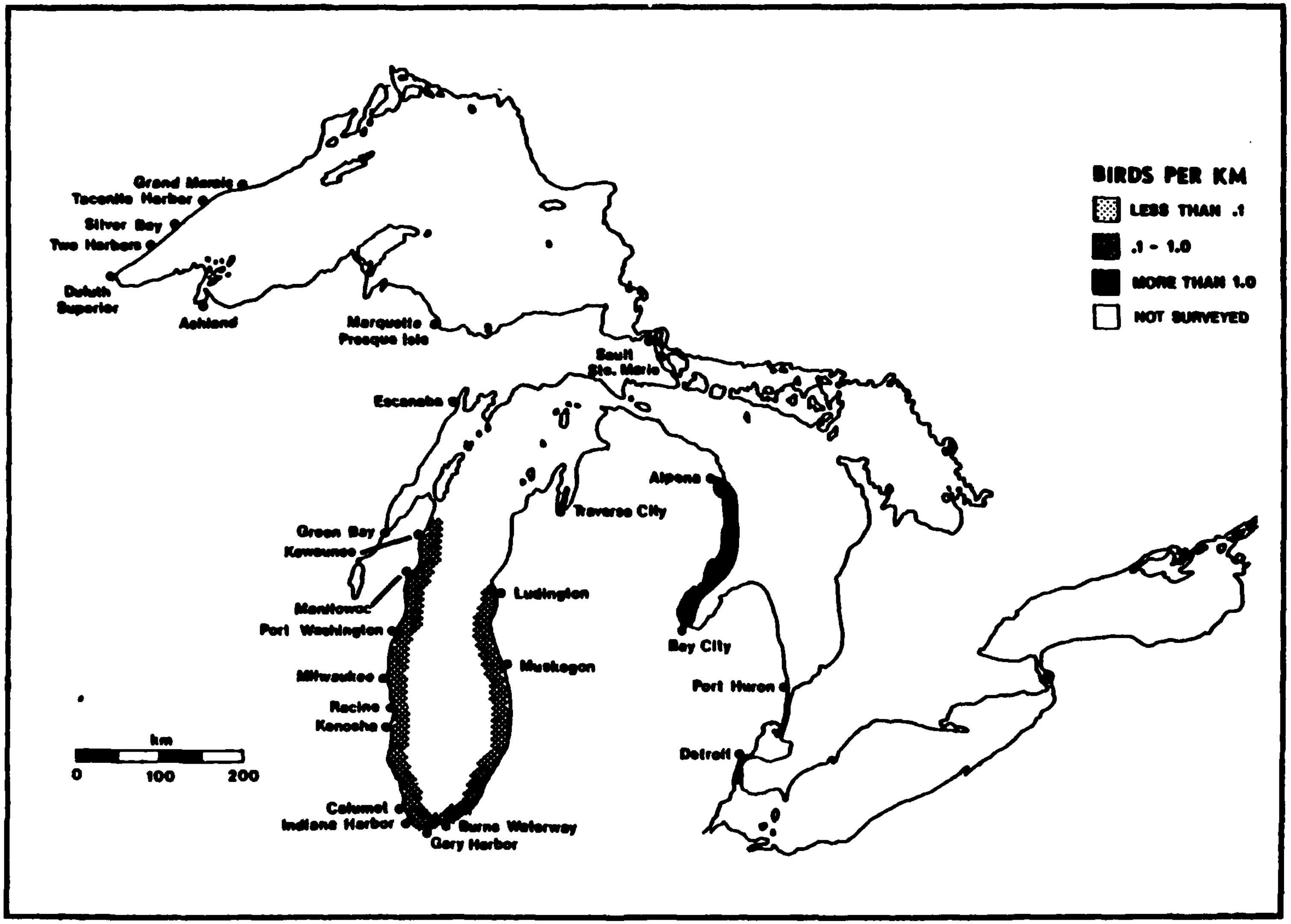


Figure 12. Number of waterfowl per km of shoreline for major lake regions (see Table 17) seen on aerial survey, early March, 1981.

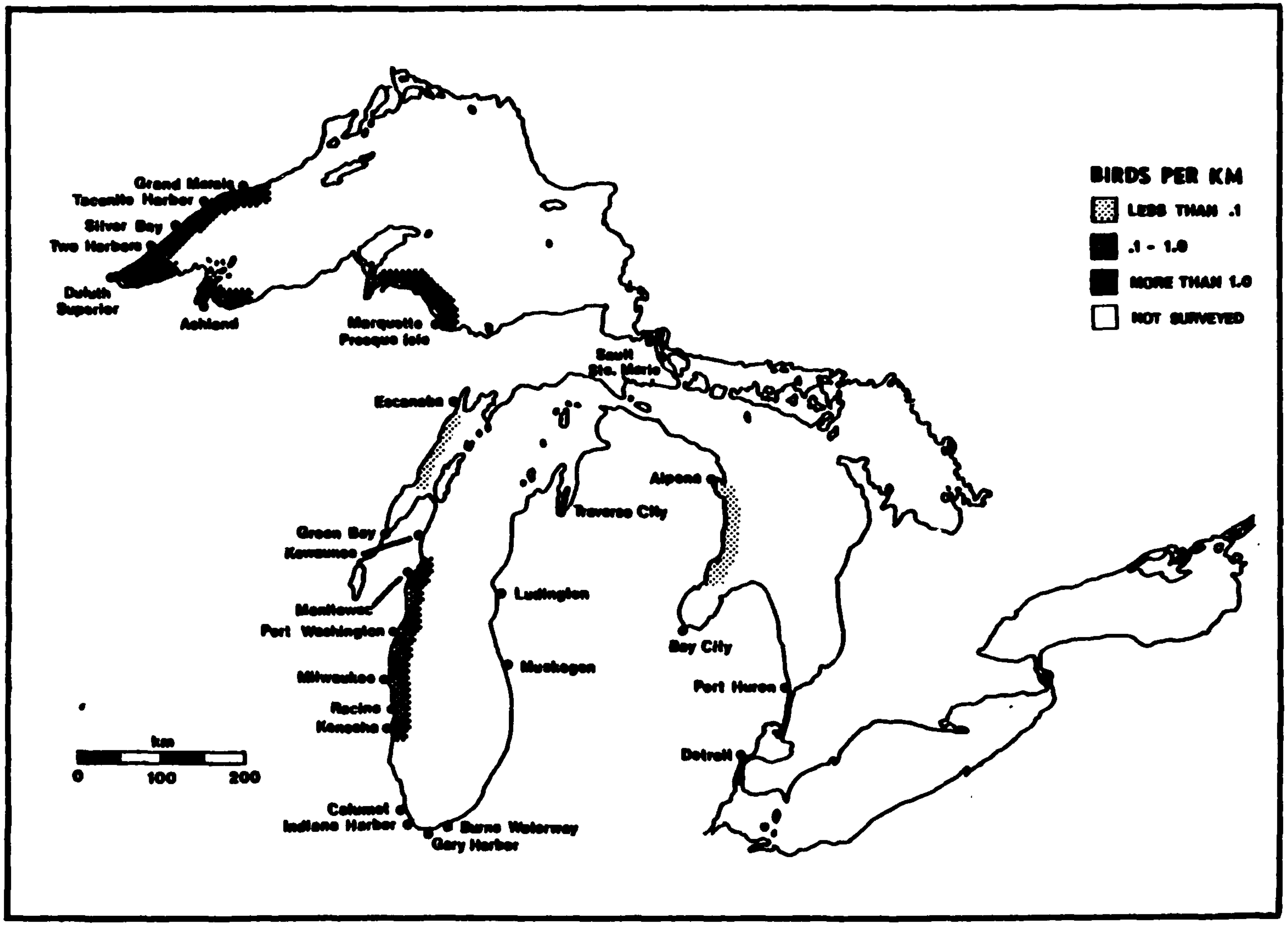


Figure 13. Number of gulls per km of shoreline for major lake regions (see Table 17) seen on aerial survey, early January,1980.

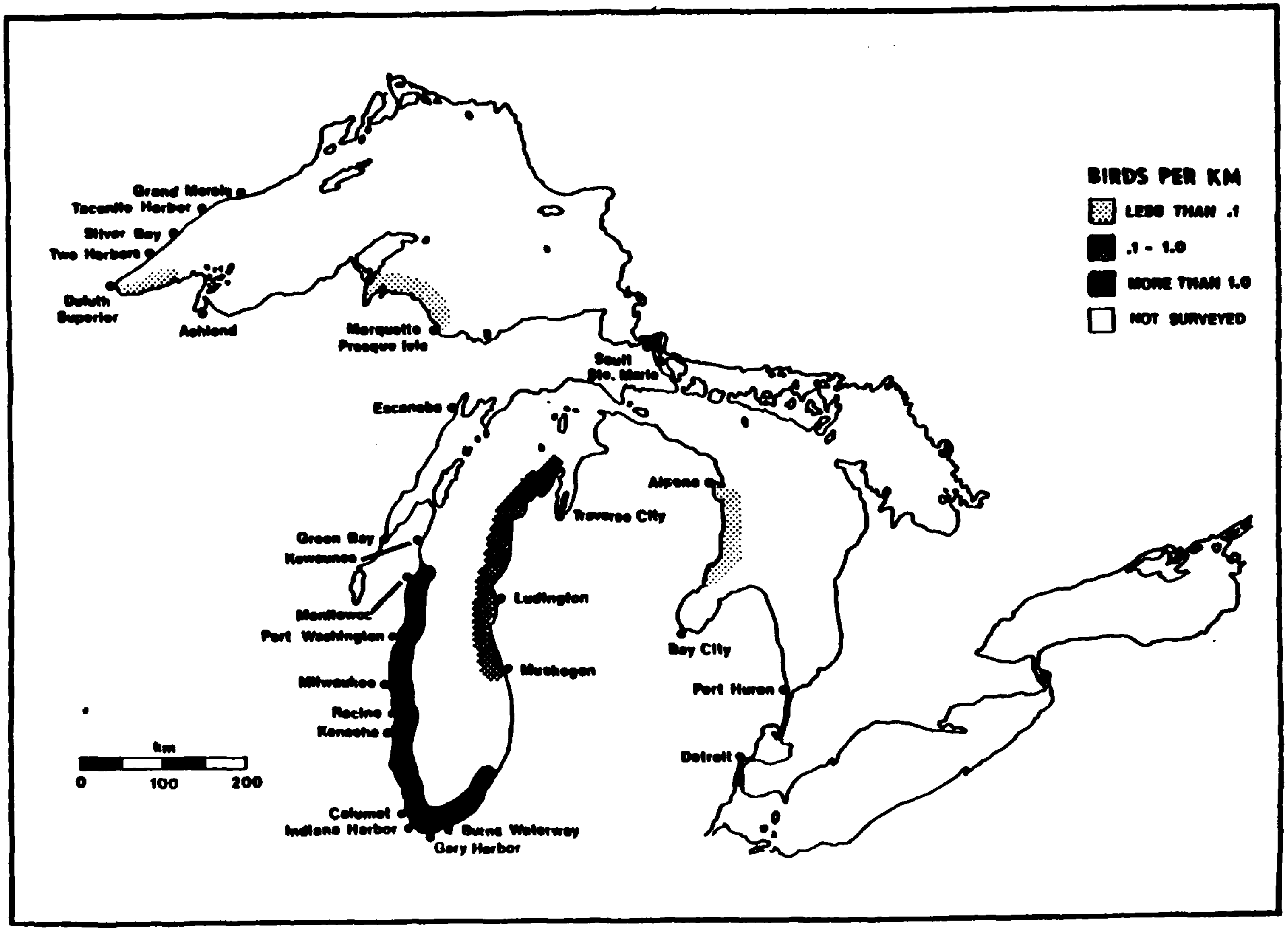


Figure 14. Number of gulls per km of shoreline for major lake regions (see Table 17) seen on aerial survey, late January, 1981.

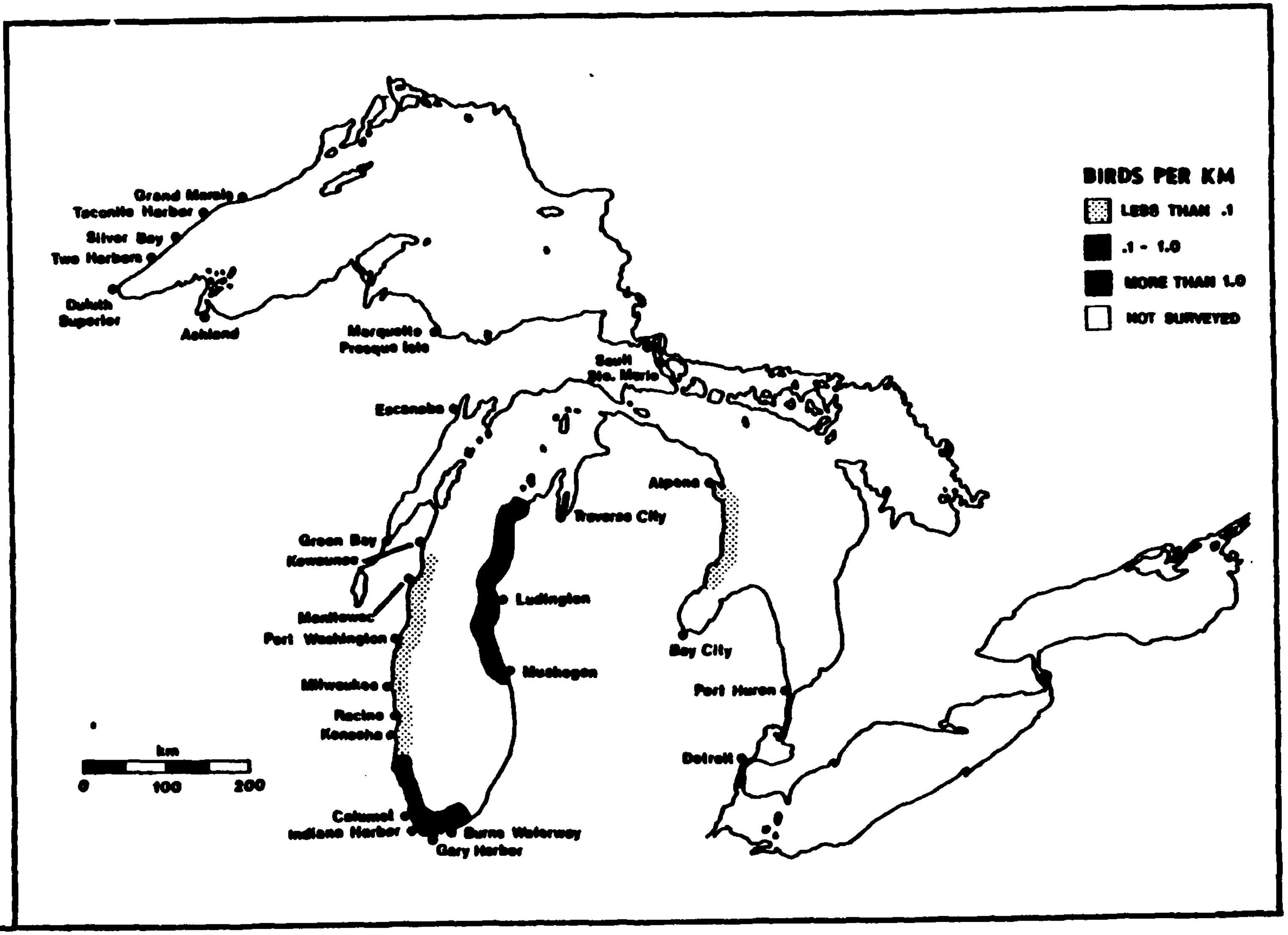


Figure 15. Number of gulls per km of shoreline for major lake regions (see Table 17) seen on aerial survey, early March, 1980.

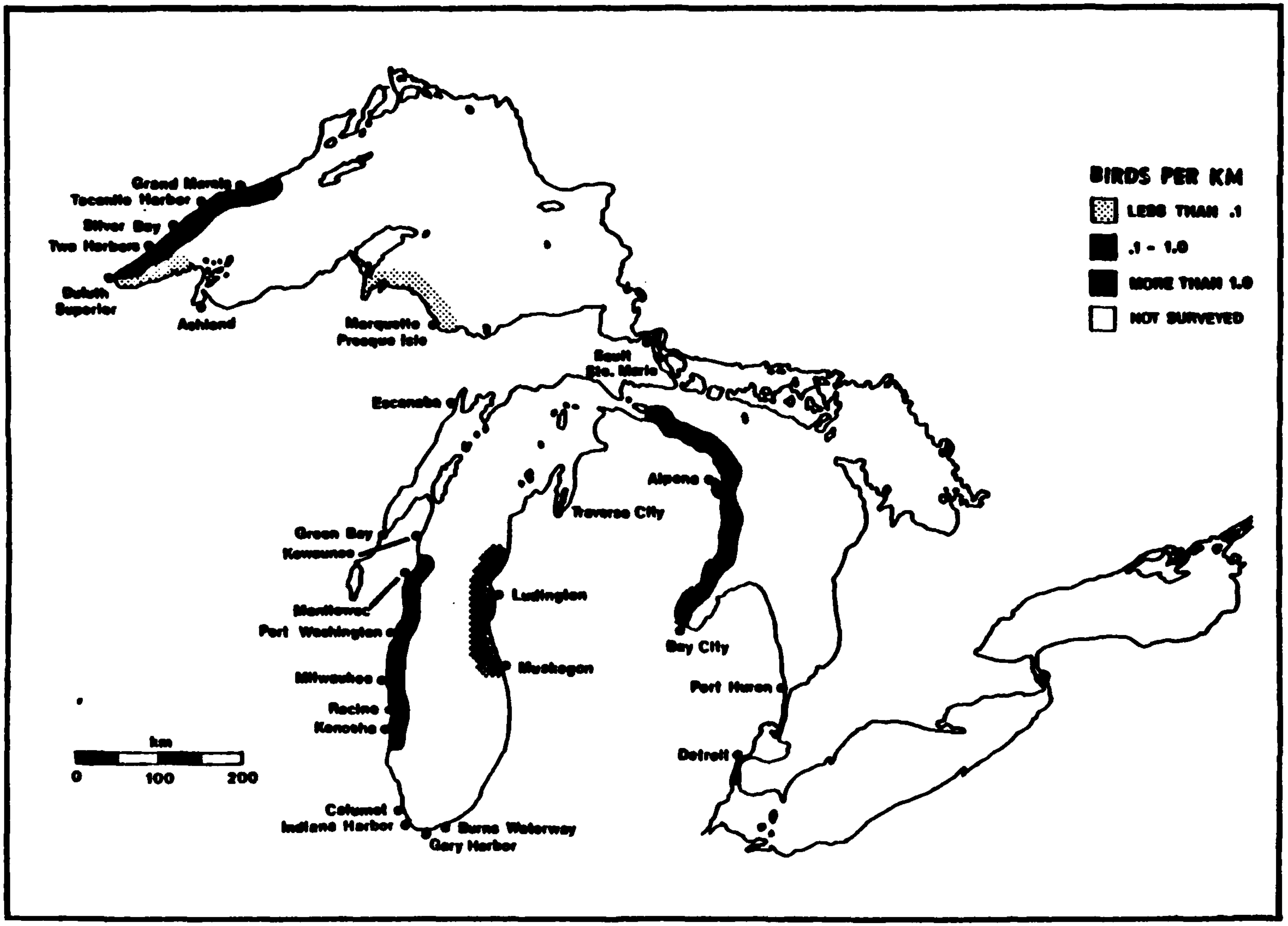


Figure 16. Number of gulls per km of shoreline for major lake regions (see Table 17) seen on aerial survey, late March, 1980.

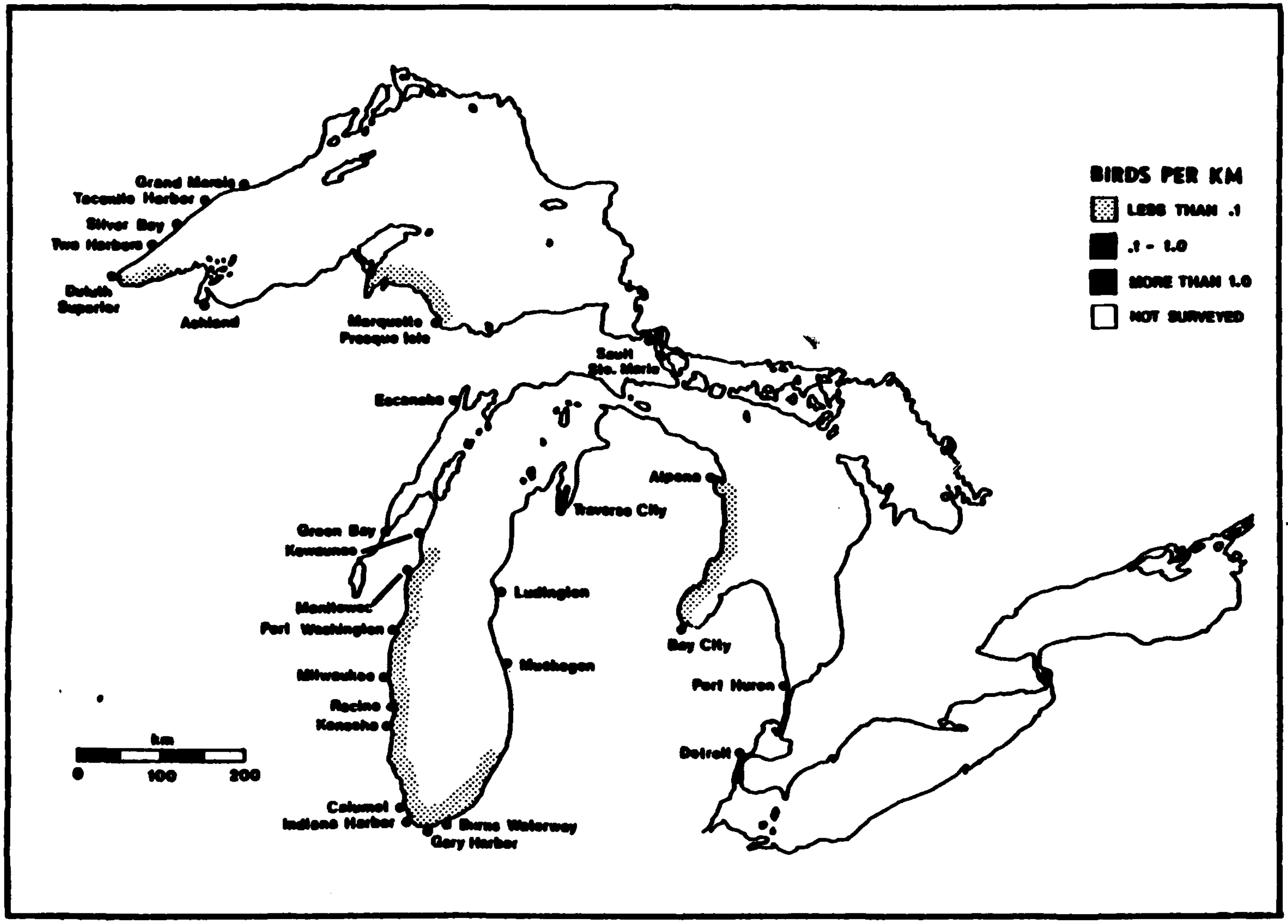


Figure 17. Number of gulls per km of shoreline for major lake regions (see Table 17) seen on aerial survey, early January, 1981.

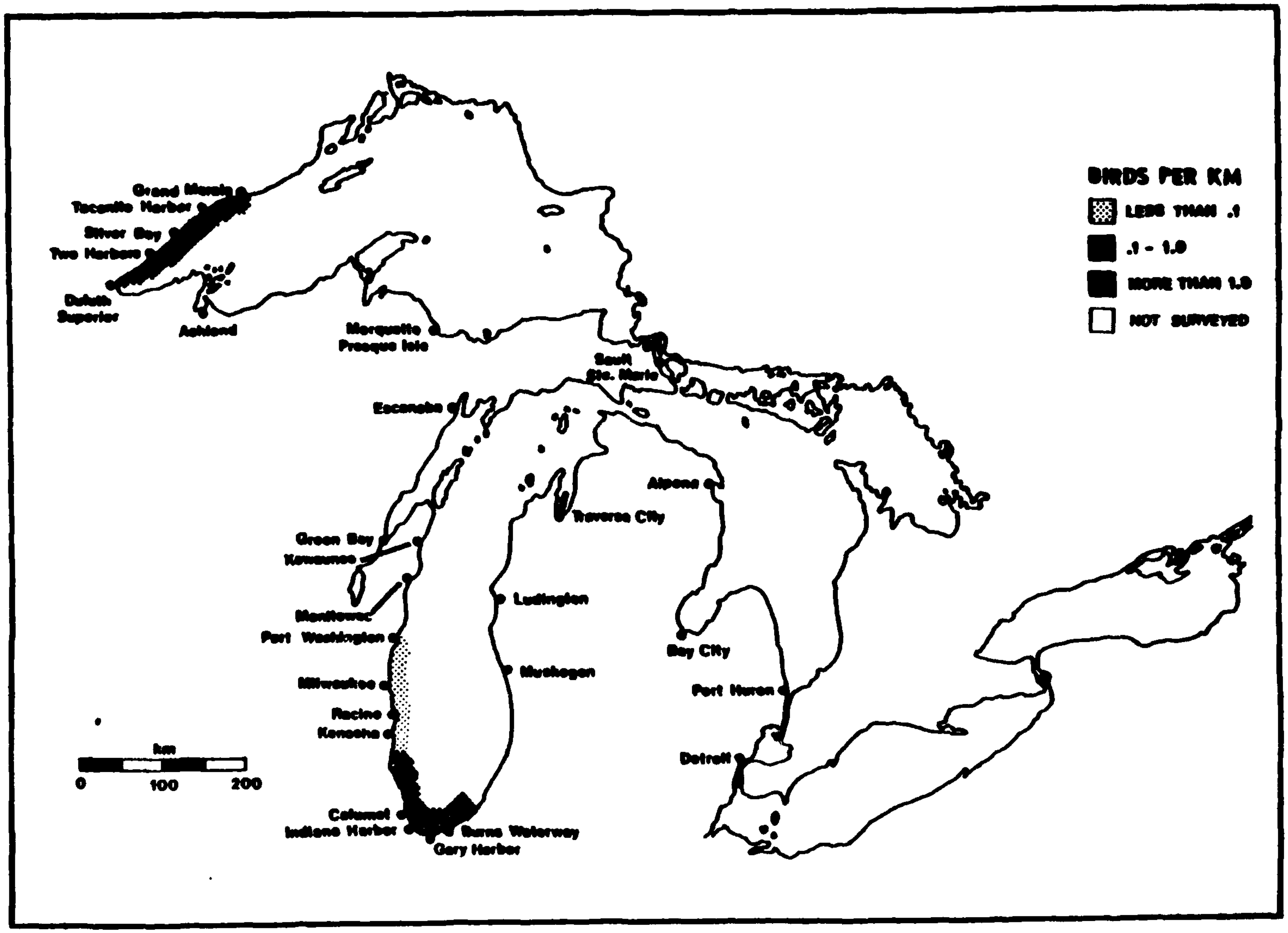


Figure 18. Number of gulls per km of shoreline for major lake regions (see Table 17) seen on aerial survey, late January, 1981.

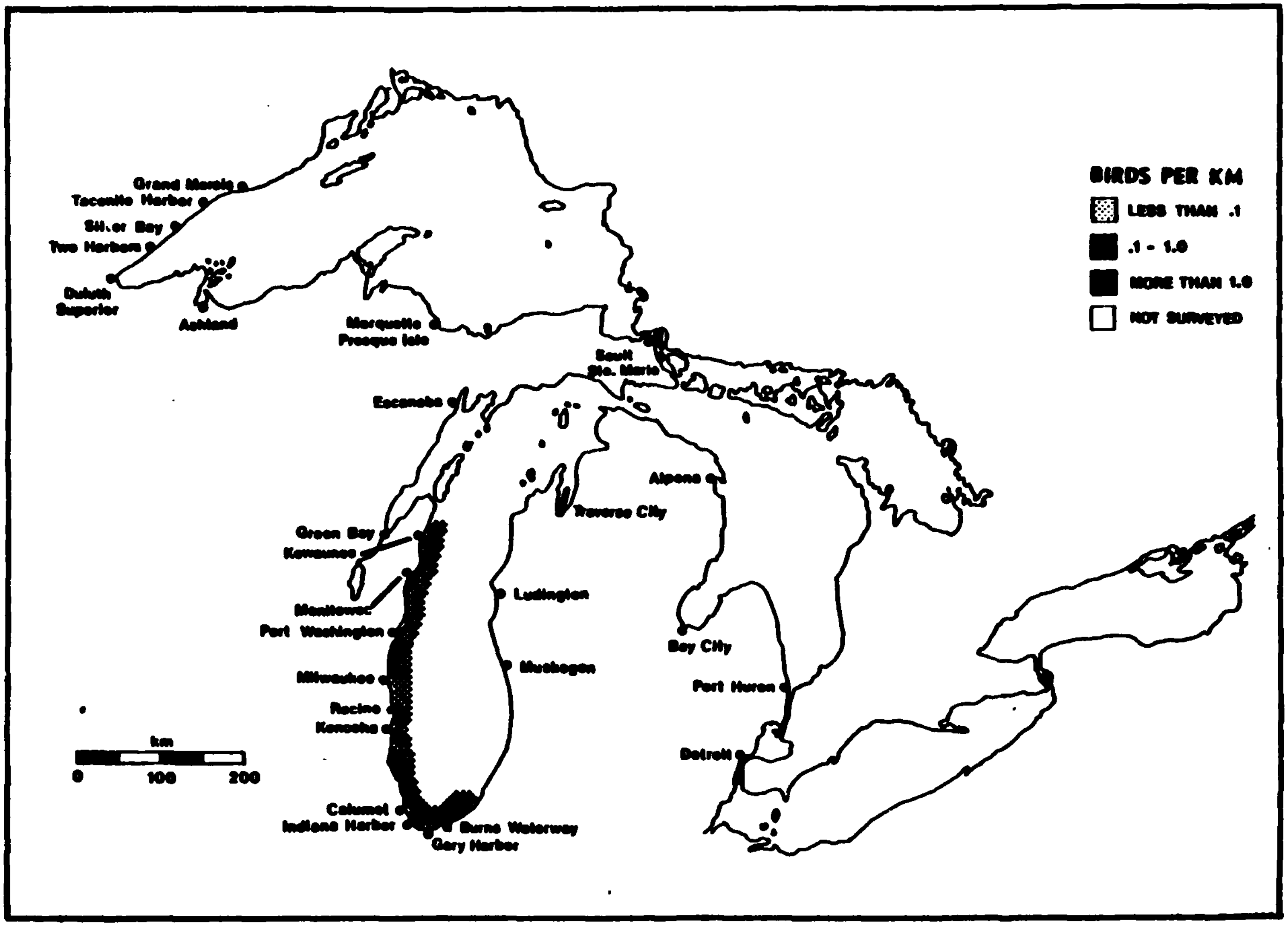


Figure 19. Number of waterfowl per km of shoreline for major lake regions (see Table 17) seen on aerial survey, early February, 1981.

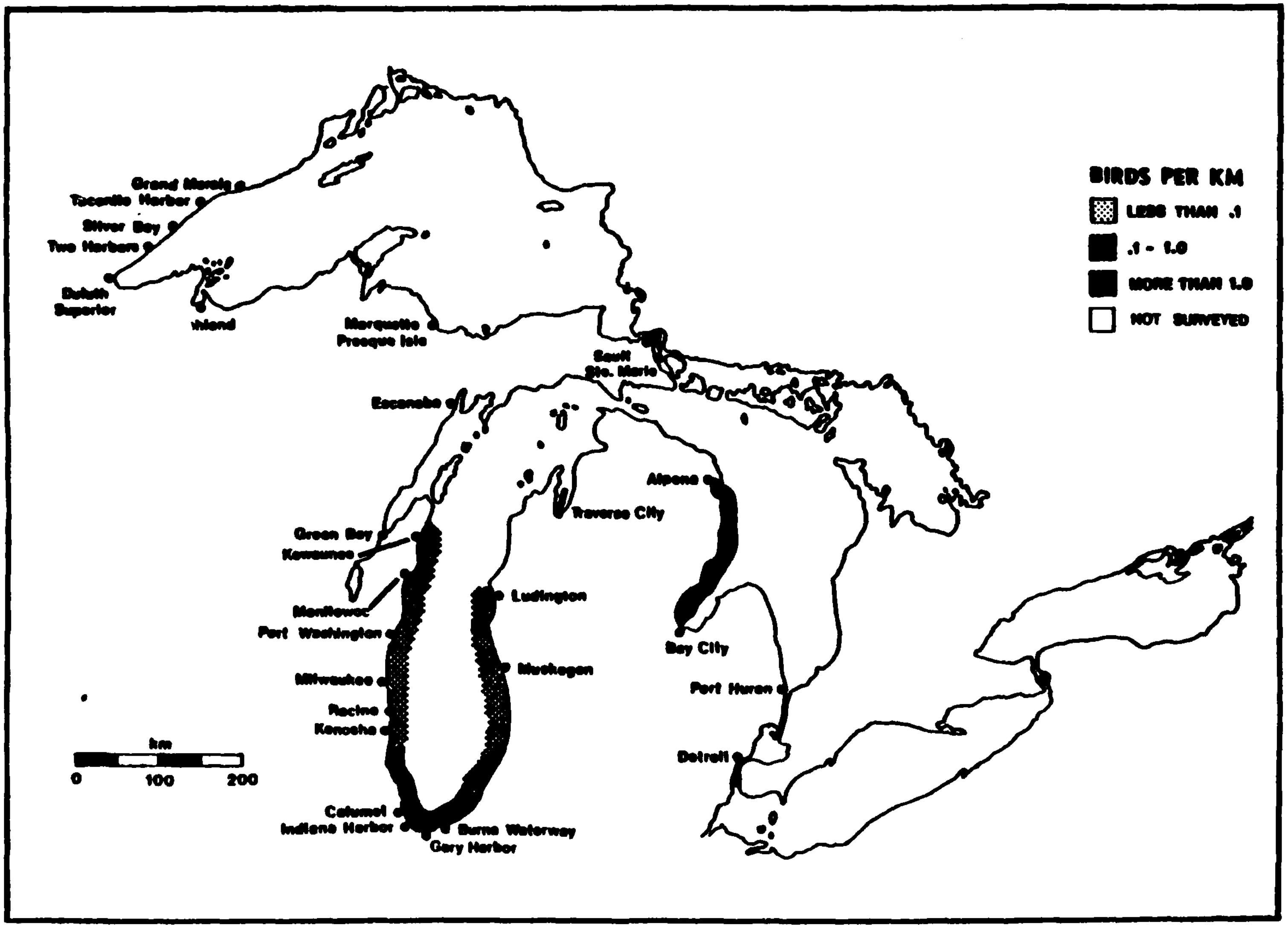


Figure 20. Number of gulls per km of shoreline for major lake regions (see Table 17) seen on aerial survey, early March, 1981

Summary of Winter Bird Use on Selected Regions and Sites (from Aerial Surveys)

LAKE SUPERIOR

Winter bird use of Lake Superior was uniformly low and limited to only a few species (Figures 5 and 6). The only areas in which significant numbers were seen were the Marquette/Presque Isle harbors, where up to 50 common goldeneye and 150 gulls were observed, the Good Harbor Bay area near Grand Marais, Minnesota, where as many as 150 oldsquaw were seen offshore, and the Duluth area where several hundred gulls were seen during the early winter months. Small groups of gulls (< 100) were often sighted near harbors along the north shore. Lake Superior harbors were ice-bound and had only isolated patches of open water due to heated effluents or river currents.

General shoreline use of the lake also was low, and was limited primarily to common goldeneye, common mergansers, and gulls (Figures 7-22). Oldsquaw probably used offshore areas, especially along the north shore, but, with the exception of those observed in the Good Harbor Bay, none were seen during surveys. The only significant shoreline use occurred in mid to late March when large numbers of herring gulls returned to breeding sites located on islands scattered throughout the north shore of the lake (Figure 22). The only raptors observed included a single bald eagle seen on Knife Island at Knife River, Minnesota in mid-January and a snowy owl sighted at Beaver Island, Taconite Harbor at the same time.

Duluth-Superior

The only open water areas in this harbor were located at the Minnesota Power and Light Hibbard Power Plant and the Western Lake Superior Sanitary District treatment plant. These areas were small (< 5 ha), and no birds were observed using them, although local observers reported a few common goldeneye on occasion. The use of this area by snowy owls has already been noted (see Historic Review).

Two Harbors

This harbor was ice-covered much of the winter and no birds were observed. It seems likely that low numbers of gulls habituated the area at times, but we had no records.

Silver Bay

As with the other north shore harbors, this site remained ice-covered much of the winter. The only bird use observed involved small groups of gulls which were seen along the taconite tailings lining the shore.

Taconite Harbor

This harbor was frozen during most of the winter. The snowy owl seen here was mentioned above. The only other birds observed were low numbers of gulls (< 25) seen in early January.

Grand Marais

This harbor was open in early winter but ice-covered by March. About 130 gulls were observed in mid-January 1980, and local observers reported that this is normal for winter use. This area also is noted for unusual sightings such as eider spp. and rare gulls, although we had no observations of these during survey work.

Ashland

Most of Chequamegon Bay was frozen throughout the winter, and the only open water present was at the Lake Superior District Power Company power plant and in the lower portions of Fish Creek. The only birds observed were a few mute swans, likely the same birds which breed here. Local observers reported a small flock of mallards used Fish Creek also, but they were not seen from the air. No birds were seen at the power plant site.

Presque Isle

Much of this harbor, including the lower portions of the Dead River, were open during early winter, but the north edge, including most of the docking facilities, was almost always ice-bound. In late winter (early March), the entire harbor was ice-bound although the lower Dead River remained open. The only bird sightings made included scattered ducks (goldeneye and merganser) in the Dead River and near the south side of the breakwater, and a few gulls, also near the breakwater.

Marquette

In early winter most of this harbor was open, although the northern section near the International Oil Company dock was ice-covered. By March the entire area was ice-covered with the exception of a small patch of open water at the Shiron Power Plant. Bird use in early winter consisted of small groups of common goldeneye (maximum of 50) and gulls (ca. 100). These birds were usually seen on the water just south of the ice border on the north shore. In late winter, the only birds seen were gulls (100-150). They used the remaining open patch of water at the generating plant.

LAKE MICHIGAN

Several areas on Lake Michigan had significant bird populations during the winter months. Sites with major concentrations included Milwaukee, Green Bay and the adjacent Fox River, and Muskegon (Figures 3 and 4). The predominant species in these areas included scaup and oldsquaw at Milwaukee, mallard, black duck and Canada goose at Green Bay, and common merganser at Muskegon.

General shoreline use was quite variable, but, due to prevailing ice conditions, the west and southwest shores supported more birds. When open water existed on the east shore, it appeared that off shore usage was as great or greater than in other areas. The predominant species in offshore areas were common merganser, common goldeneye, and oldsquaw.

Escanaba

With the exception of small areas on the lower Escanaba River, this harbor was ice-bound throughout the winter months. No bird usage was observed.

Green Bay

Most of Green Bay froze early in the winter and was ice-covered by early January during this study. Essentially all nearshore, i.e., survey areas, were ice-covered by late January. Bird usage of nearshore areas was thus restricted to early January and consisted primarily of scattered common goldeneye and common mergansers.

Green Bay (City) and Fox River

The lower portions of Green Bay and much of the Fox River were frozen throughout both winters. The exceptions to this were the mouth of the Fox River (including the Pulliam Power Plant site), areas of the river just above and below the various dams, and the upper third of the river near Lake Winnebago.

Scattered groups of common merganser and common goldeneye were seen in the open riffle areas below the dams, but the majority of the birds on the Fox River were found at the upper terminus at Lake Winnebago. Mixed groups of mallard and black duck, numbering as high as 1400, and as many as 500 common mergansers were seen between the head of the river and the point where the two main channels rejoin.

The other major bird use area was the Bay Beach Park Wildlife Refuge. The ponds here are kept open artificially during the winter, and the birds are fed by local residents. Up to 700 Canada geese, 300 mallards, and 200 black ducks were observed in and around the ponds. Although no birds were seen in the open water near the power plant, local observers reported that the refuge flock habitually uses this area at dawn and dusk. It also is likely that the mallards and black ducks seen on the upper Fox River are part of the refuge flock. The highest total count in the area was 5801 birds, and the mean was 2947 ($N = 4$).

Kewaunee Power Plant

Since the west shoreline of Lake Michigan remained essentially ice-free both winters, this site was not an isolated patch of open water as may be true in colder years. Observed bird use was minimal and limited to occasional sightings of small groups of gulls (< 50).

Port Washington

Bird use of the Port Washington harbor occurred mainly inside or immediately outside the breakwater structures and was quite variable. The mean number of birds observed was only 108 waterfowl and 43 gulls ($N = 4$). The predominant species were oldsquaw and scaup spp. Ice cover within

the outer harbor was minimal throughout the winter months. This is partially due to the presence of a power plant.

Milwaukee

The Milwaukee Harbor is well known as a major concentration area for overwintering waterfowl, especially scaup spp. and oldsquaw. During the study the mean population in the harbor was 2061. This is an underestimate since the lower Milwaukee River and park areas could not be surveyed. Local observers report large numbers of birds in these areas at times (Rofritz 1972). The major use areas varied with ice conditions, and these were quite variable. However, some areas were consistently open and were preferred when much of the outer harbor was frozen. Included are the main river channel out toward the central entrance, the inner shore immediately north of the river mouth, and a large area inside the south harbor. The winter gull population observed in this harbor was quite variable and had a mean of 216 and a high of 650.

Ice conditions were very changeable. During one survey the outer harbor was completely frozen one day and nearly open water the next day. The ice never appeared to be thick, perhaps in reflecting the influence of the sewage effluent. Wind conditions also appeared to cause marked changes in ice cover.

South Lake Michigan Harbors

Although the adjacent portion of Lake Michigan was often frozen, the harbors of the south shore generally has little ice cover. Bird use was low. The only significant concentration included about 200 common mergansers seen at Gary in late January 1980. Scattered groups of mallards and gulls were were also seen, but they numbered only in the few hundreds with the exception of early March 1981, when large numbers of gulls (ca. 1000) were observed. The increase in gulls probably marked the return of migrants.

Muskegon

Most of Lake Muskegon was ice-bound throughout the winter months. Several small open-water areas did exist, but the only areas of significant bird use were the Consumer's Power Plant at the east end of the lake and the open riffle areas along the Muskegon River. Several hundred waterfowl, primarily common mergansers, and gulls used the power plant site throughout the winter months. The mergansers also habituated the river area. No birds were observed in the settling ponds located a few miles upriver from the lake. Car ferry tracks appeared to freeze over quickly and therefore did not influence bird distribution. Small flocks of mallards and a few mergansers did use open water near the entryway into the harbor.

Ludington

With the exception of a few small open areas, Lake DePere was ice-covered throughout the winter months. The primary bird use was by gulls, but even this was minimal. Car ferry tracks appeared to freeze over quickly and therefore did not affect bird distribution.

Traverse City

By early January, the lower portion of Grand Traverse Bay was frozen, although the remainder was open both winters. Open water in the lower bay was found at the mouth of the Boardman River as well as at various points upriver, and at the Holiday Inn. These open waters were used by waterfowl, including as many as 1000 mallards and 500 mute swans. The mallards were primarily seen at the mouth of the river and at the Holiday Inn, while the swans used the river area. Local observers reported as many as 700 mute swans. All these birds are fed by local residents and are dependent upon them for their survival. Few birds were observed in the open waters of the upper bay.

LAKE HURON

With the exception of the J. C. Weadock Power Plant site at Bay City, few birds overwintered on Lake Huron, and diversity was quite low. Shoreline areas were used by common goldeneye and common merganser, but numbers were low.

Alpena

Significant portions of Thunder Bay, including those areas near Alpena were ice-bound throughout both winters. Thus the only open water near the harbor was found in small patches below dams on the Thunder Bay River and near the mouth of the river. Only scattered mallards, goldeneye, and mergansers were observer during surveys, although local observers reported several hundred mallards and up to 200 Canada geese winter within the city.

Bay City - Saginaw Bay

Much of Saginaw Bay was frozen throughout the winter months. The only consistently open water was found at the J. C. Weadock Power Plant effluent, and this was the only area used by a significant number of birds. Several hundred mallard and black ducks and up to 4,000 common mergansers used this site.

Detroit-St. Clair System

This area is a well-known traditional overwintering site for large groups of waterfowl and had the highest population of any site within the Upper Great Lakes during both winters of the study. From 27% to 84% of the total waterfowl count per given survey, including shoreline areas, was observed here. Total numbers ranged from about 1000 to almost 40,000 birds.

Specific locations within the area which were used most heavily were the lower St. Clair River (delta area) and immediately adjacent portions of Lake St. Clair (Anchor Bay), and the lower Detroit River near Cleron, Grassy, and Swan Islands. Power plant sites did not appear to be preferred usage areas.

The predominant species in descending order of abundance were canvasback, redhead, mallard, scaup, common goldeneye, and common merganser. Several hundred gulls also wintered in the area. Other species of interest which wintered here, but in moderate numbers, included the whistling swan and Canada goose. A more detailed discussion of winter use of the lower Detroit River was presented earlier in a separate portion of the report (see Detroit River-Ground Surveys).

ST. MARY'S RIVER

Since little inter-lake shipping took place during the two winters of this study, ship passage did not play much of a role in ice conditions or bird distribution. In those cases where ship passage was observed, open water behind the vessel filled in with ice almost immediately.

Open water areas and bird use sites were described by Robinson (1979). The primary use areas were the north channel near Bellevue Park and the rapids. A few hundred birds overwintered both years, and the dominant species were common goldeneye, merganser spp., and mallard. Two separate sightings of an adult bald eagle in the Bellevue Park area were made in 1981.

Species Accounts

Canada Goose. The only major wintering site for this species included in the aerial surveys was the Bay Beach Park Wildlife Refuge Green Bay where up to 700 birds were observed. These birds are fed by local residents, but also field-feed in nearby areas. From 50 to 150 birds were also seen regularly on the Detroit River, primarily near Horse Island. Migrants began arriving in early March, and up to 350 were seen along the east shore of Lake Michigan during this time. Most of the latter birds were observed near the various rivers and small municipalities scattered along this shore. The late March survey conducted in 1980 found large numbers of geese at traditional stopovers such as Fish Point (near Bay City) and the Shiawasee Wildlife Refuge.

Mallard. Mallards were observed throughout the study. Most large concentrations were associated with power plant sites, harbors, and/or areas where they were fed by residents (e.g., city parks). The major concentrations (several hundred birds) were found in the Detroit-St. Clair River area, Bay Beach Park Wildlife Refuge, the Upper Fox River, Traverse City, and Bay City. The total population per survey was consistently near 3,000 birds.

Black Duck. Significant numbers of this species were found in only a few areas. Included were Green Bay (Bay Beach Wildlife Refuge) and the Upper Fox River, Bay City (J. C. Weadock Power Plant), and the lower Detroit River. Populations in these areas were normally from 100 to a few hundred birds.

Redhead. The only major winter population of this species on the upper lakes was found in the Detroit-St. Clair System. A few redheads were observed on the southwest shore of Lake Michigan (Racine) in early January 1980 also. Winter population census figures ranged from 6,000 to near 12,000 in 1979-80 and from 2,000 to near 4,000 in 1980-81. The 1979-80 population was appreciably higher, possibly a reflection the mild early winter conditions of that year. From several hundred to 2,400 were observed at the nearby Monroe power plant in western Lake Erie during the censuses conducted in 1980-81. These birds may actually move between this site and the Detroit River.

Canvasback. As with the redhead, the only major winter population of this species was found in the Detroit-St. Clair System. The winter population census figures fluctuated widely, with large numbers occurring in early January and early March. Again, the population was much larger in 1979-80. Actual overwintering numbers were on the order of a few thousand. Occasionally, large numbers (up to 1350) of this species were also seen at the nearby Monroe power plant.

Scaup spp. Scaup were observed primarily in two areas, the harbors on the southwest shore of Lake Michigan (especially Milwaukee) and the Detroit River area. Although species identification was not possible from the air, ground observations over the past several years indicate that these birds were probably greater scaup. The largest population was found in Milwaukee which has long been known as a major overwintering site for scaup. A few thousand birds were observed in the harbor, although numbers fluctuated due to weather, ice conditions, etc. The number of scaup in the Detroit

River area also appeared to vary appreciably with maximum number of 600 observed from the air (ground observers (see next section) reported as many as 2000). Scaup numbers increased dramatically in March with the influx of migrants. No scaup were observed on the east shore of Lake Michigan (e.g., Ludington, Muskegon) although past records do indicate occasional congregations in these areas.

Common Goldeneye. This species was seen scattered throughout the shorelines of all areas. The only large concentrations observed were on the lower Detroit River and the open track of water between this area and the Monroe power plant. Several hundred birds were seen in these areas during early January. The population on the Upper Great Lakes dropped markedly after January (Figure 4), as total survey numbers fell from more than 1000 to less than 300 both years. This pattern was also noted by Robinson (1979).

Common Merganser. This species was seen both in large concentrations and in scattered groups in most shoreline areas. The large concentrations were primarily associated with power plant sites including those at Bay City, Muskegon, and Monroe. From several hundred to a few thousand birds used these sites. The only other major concentration occurred on the upper Fox River where several hundred to more than 1100 birds were seen, although not consistently. Survey totals for this species were usually between 4000 and 6000 birds.

Oldsquaw. The only large concentrations of oldsquaw were observed in the Milwaukee Harbor and in the Good Harbor Bay area on the north shore of Lake Superior. Milwaukee had the largest population, numbering from several hundred to a few thousand birds. Ice and weather conditions affected survey totals appreciably, but it appeared that oldsquaw utilized the harbor throughout the winter months. The oldsquaw seen in Good Harbor Bay numbered only a few hundred, and they were seen only in January, 1980. In addition, small groups (40-250) of oldsquaw were occasionally observed in the Port Washington Harbor. Scattered groups were also noted along shoreline areas, especially the southwest shore of Lake Michigan, but total numbers were quite low.

Swans. The two wintering species of swan (whistling and mute) were quite difficult to distinguish from the air, therefore species identification relied on reports from ground observers. The only major population of mute swan was found in Traverse City. These birds are feral and nest in the upper Lower Peninsula of Michigan. Traverse City has been a traditional wintering site for a number of years. The birds rely on food supplied by local residents. Several hundred mute swans overwintered at this site during this study. The only other verified sightings of mute swans were made at Ashland, Wisconsin. A few (< 10) birds overwintered here and probably represent adults which nest in the city park. The only major winter site for whistling swans was the lower Detroit River. Approximately 200 birds used this area both years.

Detroit River - Ground Surveys of Waterfowl Distribution

Methods. Ducks, geese, and swans wintering on the Detroit River were censused during the months of January, February and March 1980 and 1981. During 1980, the census route ranged from the northern end of Belle Isle to the southern tip of Grosse Isle. The southern boundary was extended slightly in 1981 to include Horse Island (Gibralter) and a small additional portion of Lake Erie shoreline north of Point Mouilee (Figure 21).

Counts of waterfowl were made from permanent observation points located at 1.5 to 3.0 km intervals along the census route (Figure 21). The distribution of observation points enabled the observer to count all waterfowl on the river within the boundaries of the census route except those along the east sides of Grassy and Fighting Islands. An effort was made to census birds twice weekly, however, prolonged periods of high waves or dense fog often made it impossible to obtain more than one count during a one week period. Each census began between 0700 and 0800 and was completed within 4 to 8 hours. Binoculars or spotting scopes were used for species identifications.

Means and standard deviations were calculated for all waterfowl species to assess annual variation. The Student t-test was used to test differences between mean numbers of individuals per species in 1980 and 1981. This test was also used to determine whether there was any significant difference between the number of males and females of a given species in 1981. One-way analysis of variance was applied to determine the effect of various climatological parameters on the distribution of ducks on the river during the 1981 season.

Several statistical comparisons of ground and aerial survey data (see AERIAL SURVEY section) were made also. When possible, same-day counts were used, but in most cases, aerial and ground data were not gathered on the same date. In these instances, the nearest data points were used (up to 2 days apart).

Total waterfowl counts on the river were compared using a Model I regression (Sokal and Rohlf 1969) assuming the ground counts were far more accurate as to actual numbers than the aerial surveys. Relative abundance of the dominant species ($\geq$ 200 individuals) was compared using Kendall's Tau value. If ground data were not available for dates within two days of a given aerial survey, no comparison was attempted. Similarity was judged significant at $p \leq 0.05$.

Spatial usage of the river, as indicated by the two census methods, was also compared. For this purpose, the river was subdivided into three major sections - the Belle Isle area, the Fighting Island area, and the Grosse Isle area (Figure 22). For each survey, each area was ranked by total waterfowl population using each survey method. Again, comparisons were made only when data sets within 2 days of each other were available.

Results. The waterfowl that winter on the Detroit River usually congregate by January and if the weather and ice conditions permit, (Figure 23) they remain on the river throughout January, February and early March. The mean number of waterfowl observed on the Detroit River was 11,784 per

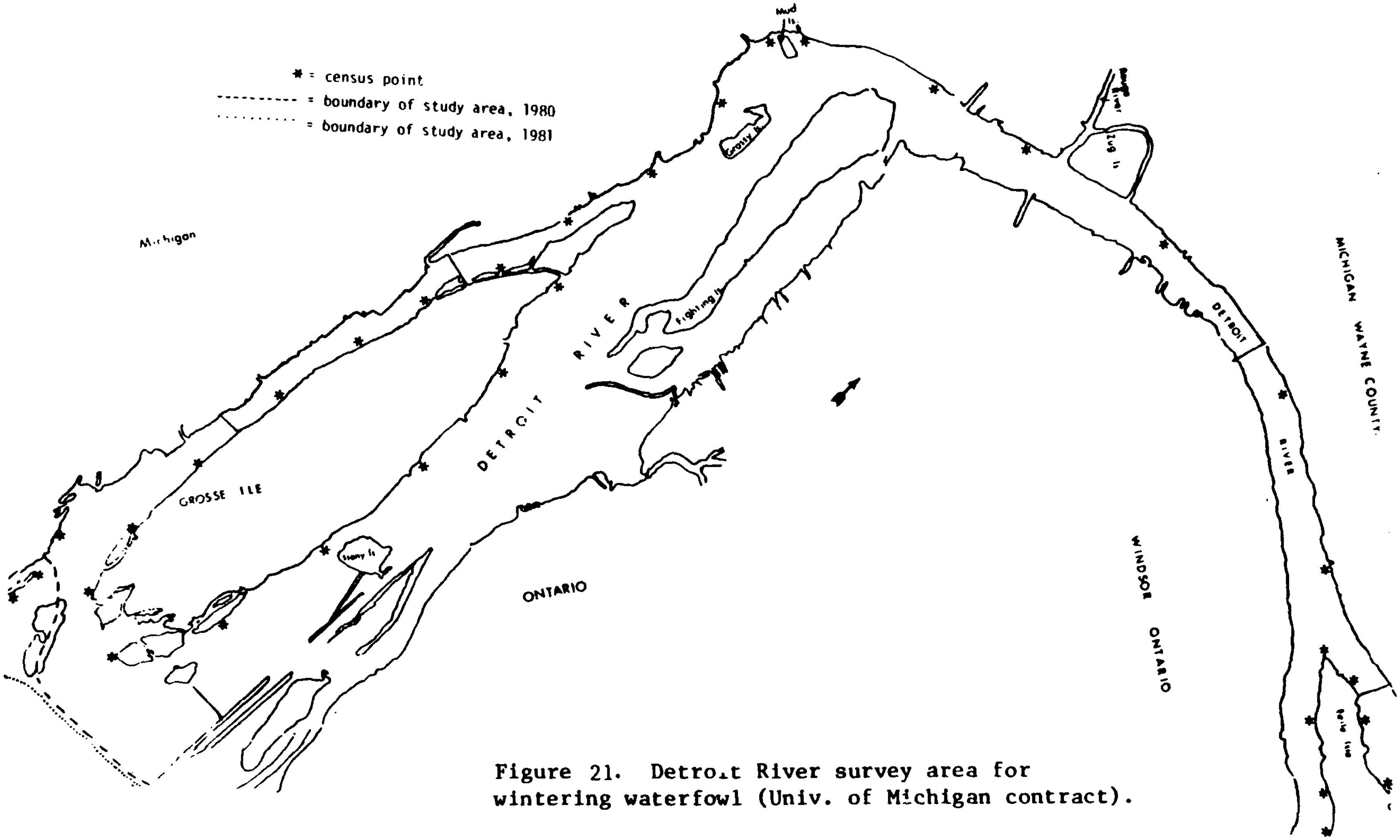


Figure 21. Detroit River survey area for wintering waterfowl (Univ. of Michigan contract).

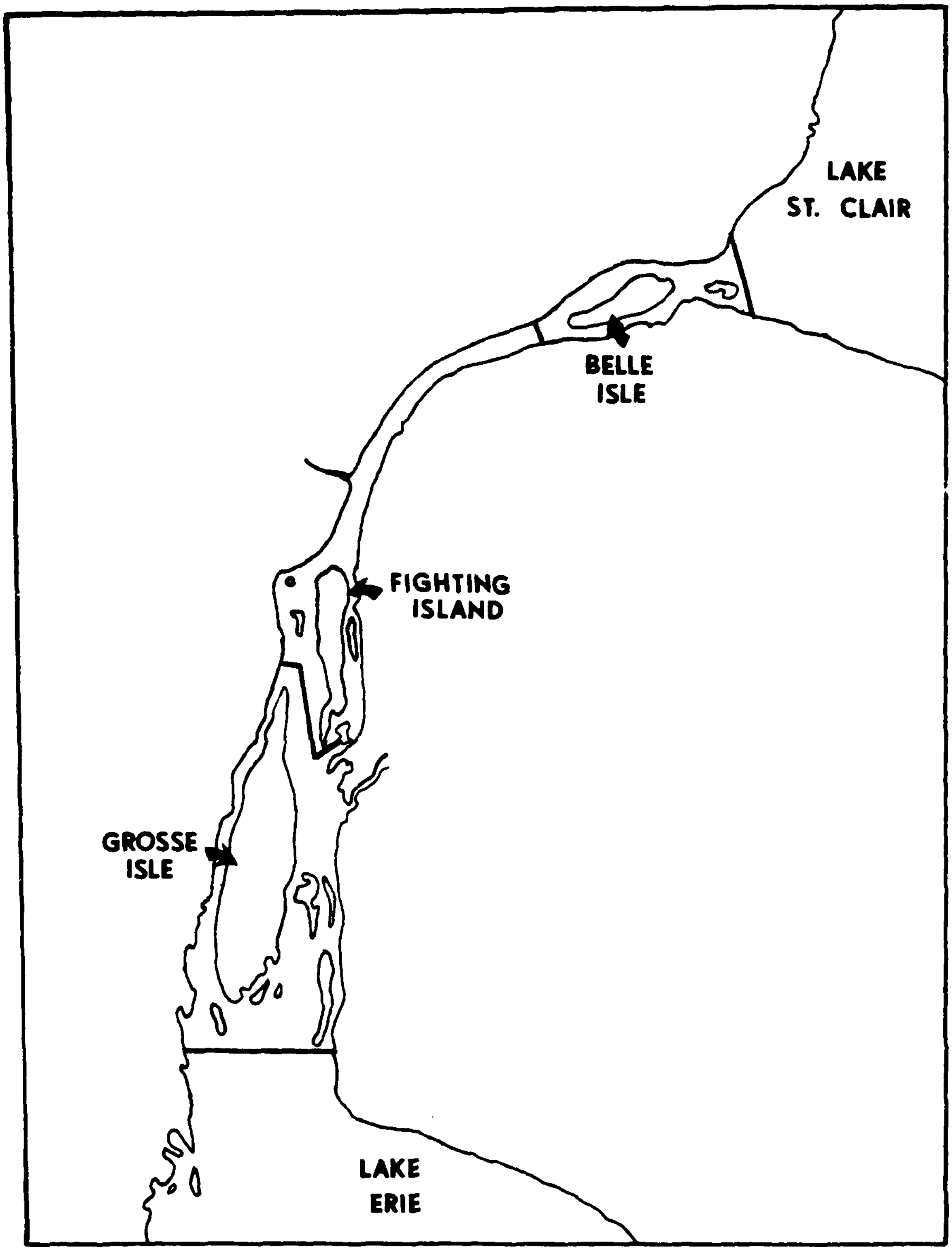


Figure 22. Aerial subdivisions of Detroit River used to compare aerial and ground surveys.

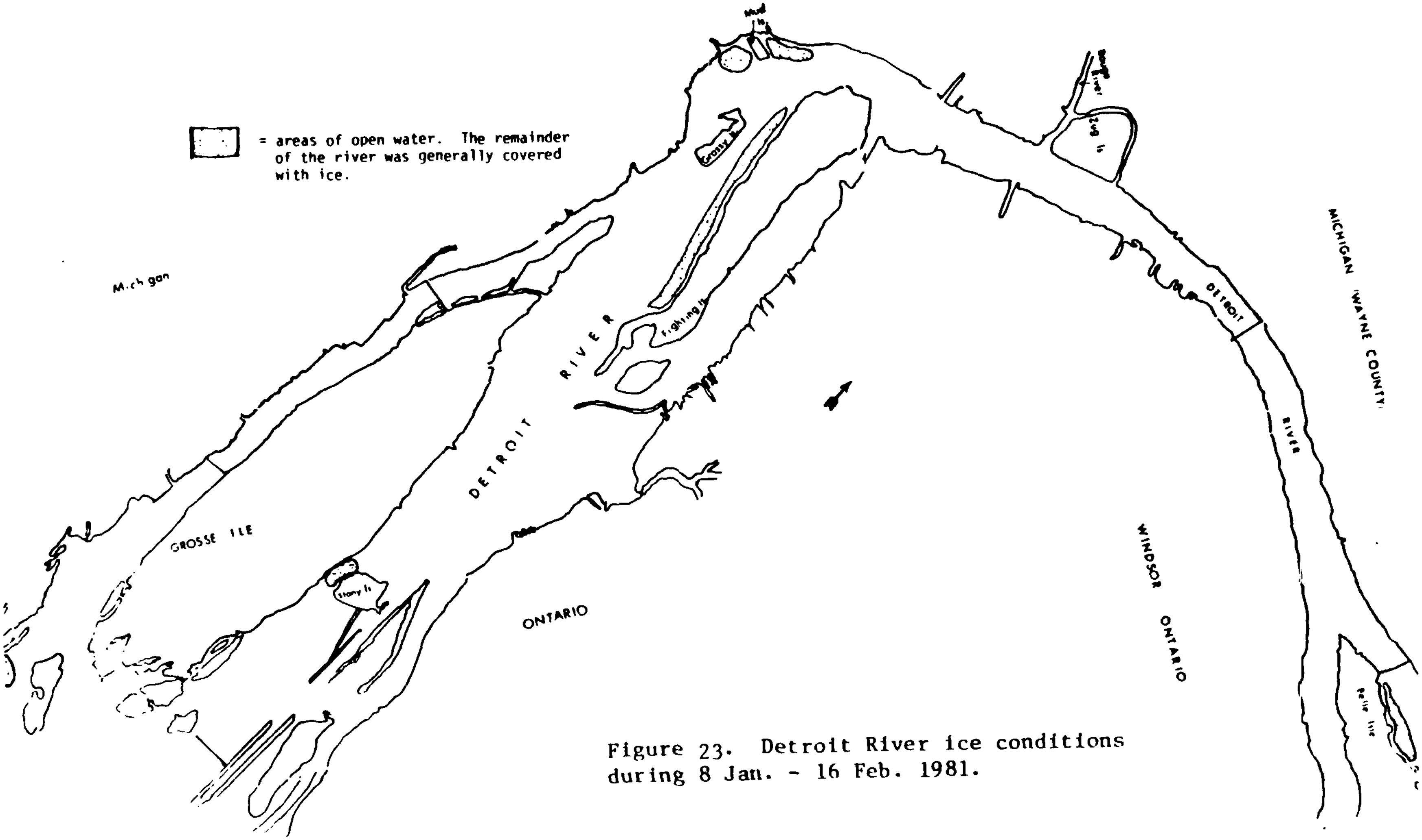


Figure 23. Detroit River ice conditions during 8 Jan. - 16 Feb. 1981.

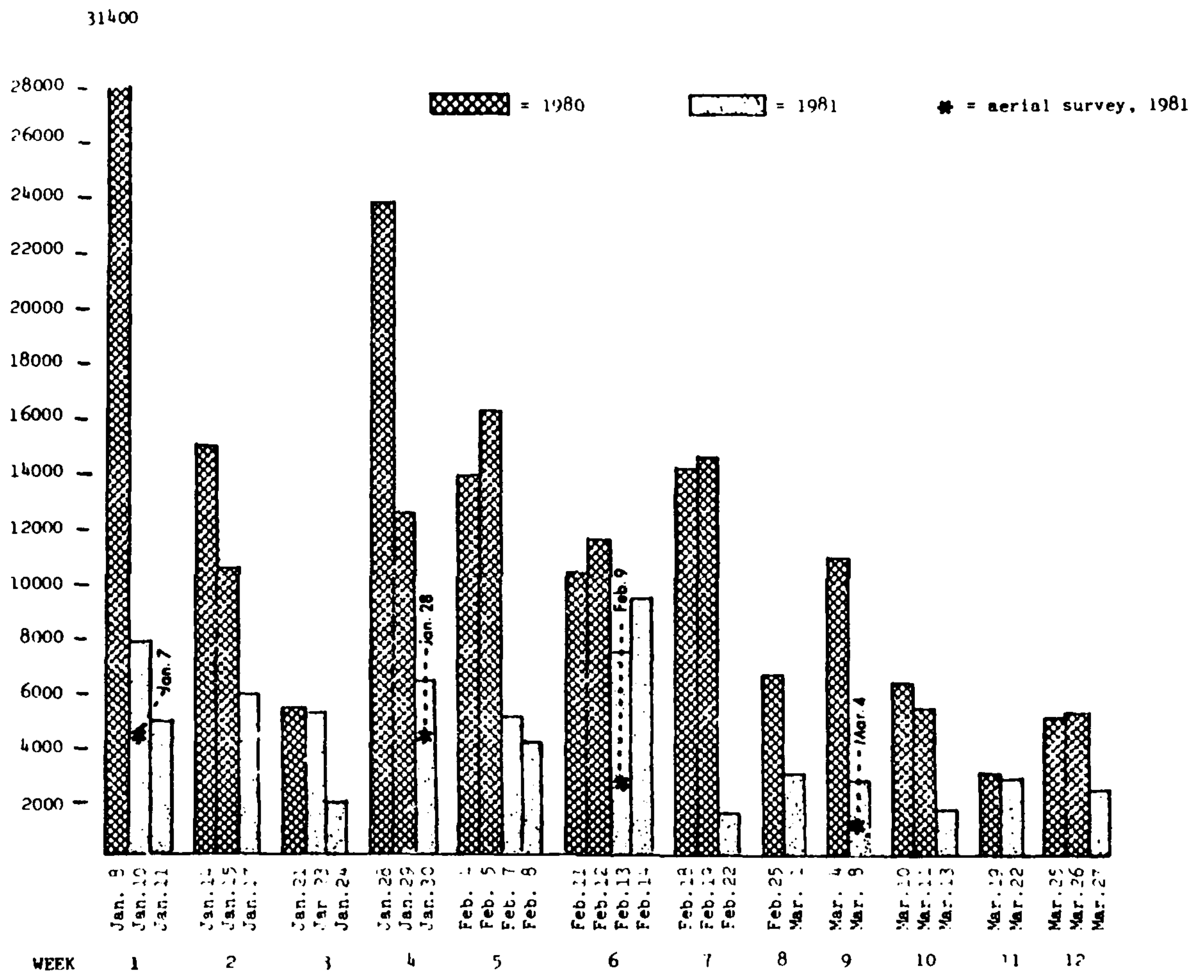


Figure 24. Total number of waterfowl on the Detroit River, showing both ground counts (Univ. of Michigan) and aerial estimates.

census in the winter of 1980, vs. 4,517 per census in winter 1981. Figure 24 shows weekly counts during the two years. The differences in temperature (Table 20) and ice cover during the early winter months of 1979-80 and 1980-81 probably account for the differences in the numbers of waterfowl wintering on the river during these two winters. When free of ice (January and February, 1980) the river supported far more waterfowl than when covered (early 1981).

The occasional wide variation between the two censuses within a given week (e.g, 5590 waterfowl on 23 Jan. 1981 and 2375 waterfowl on Jan. 24) can generally be attributed to either short-distance movements or weather conditions that affected visibility. Climatological conditions such as snow, rain, fog and waves made it difficult to identify and accurately count large rafts of diving ducks located 1 km or more from the nearest observation points. In addition some diving duck movement was attributed to response to weather conditions. For most species, there were no significant differences in mean numbers at a site due to factors such as wind velocity, wind direction, precipitation and cloud cover. Canvasbacks, however, were observed in significantly higher numbers when the wind was from the NE or SSW. On census days when westerly winds were strong (> 25 km/hr) large canvasback flocks may have gathered out of sight on the east sides of Grassy or Fighting Island. This is supported by observations made along the Ontario side of the river on March 2, 1981. During this observation period, the wind was gusting from the west, and about 3000 diving ducks (mainly canvasbacks) were sighted along the relatively sheltered east side of Fighting Island.

During 1980, large flocks (> 500 individuals) of diving ducks were seen consistently on the river (Appendix Table B1). Flock sizes diminished as the winter progressed, but the ducks persisted in large groups. In 1981, large flocks of divers (with the exception of common mergansers) dispersed during ice break up (February 16-20). These ducks may have spent the remainder of the season on the open waters of Lake Erie. The March 4 aerial census (see Aerial Surveys) did not reveal any diving ducks along the NW shore of Lake Erie, however the area near Pt. Mouilee and Monroe was heavily used by waterfowl during January and February.

A summary of the waterfowl censuses by species is presented in Table 21. There were significant differences between the mean numbers of goldeneye, scaup, canvasback, redhead, common merganser, mute swan, whistling swan and Canada goose between the winters of 1980 and 1981. High standard deviations are due to the already discussed effect of weather on the accuracy of counts, and to the wide variation in numbers of waterfowl from January to the beginning of northern migration in late March. There were no significant differences between numbers of bufflehead or *Anas* species (mallard, black duck, gadwall and wigeon combined) between the two winters. Numbers of rarer species (e.g., hooded merganser, ruddy duck) were too low and heterogeneous to be statistically tested. These counts are presented in Appendix Tables C1 and C2.

Waterfowl tended to congregate in specific areas on the Detroit River The majority of these areas were located in the southern half of the river from Gibralter (NW Lake Erie) north to Ecorse, and were generally the

Table 20. Detroit River Area Weather Statistics, Winters 1979-80 and 1980-81[a].

Weather parameter	Dec. 1979	Dec. 1980	Jan. 1980	Jan. 1981	Feb. 1980	Feb. 1981	Mar. 1980	Mar. 1981
Temperature° C								
mean	0.4	-3.2	-3.7	-7.0	-5.2	-1.8	-0.1	2.4
min.	-3.3	-7.2	-7.1	-10.6	-8.6	-5.6	-4.0	-2.1
max.	4.0	0.9	-0.3	-3.1	-1.8	2.1	3.8	6.8
rain (mm)	74.8	40.3	16.0	0.2	13.4	55.1	87.5	28.7
snow (cm)	11.6	28.0	18.2	22.8	18.8	25.8	24.2	5.0
avg. wind speed (km/hr)	18.8	16.0	19.7	15.2	18.2	19.9	21.6	19.1
wind direction	SSW	variable	W	SSW	SW	SSW	WNW	WNW

[a]Source: Evironmental Canada Weather Office, Windsor Airport, Windsor, Canada.

Table 21. Summary of Detroit River waterfowl censuses, January - March, 1980 and 1981.

Species	N[a] 1980	N[a] 1981	Mean ± S.D. 1980	Mean ± S.D. 1981
Goldeneye	19	16	990 ± 777	645 ± 460
Scaup	19	16	1345 ± 1333	379 ± 413
Canvasback	19	16	6245 ± 5273	907 ± 1345
Redhead	19	16	1748 ± 869	559 ± 523
Bufflehead	19	15	24 ± 12	25 ± 20
Common merganser	19	16	146 ± 121	609 ± 364
Anas spp.	19	16	610 ± 376	511 ± 289
Red-breasted merganser	13	7	7 ± 11	34 ± 81
Hooded merganser	11	5	2 ± 0	2 ± 1
Ruddy duck	2	3	2 ± 1	11 ± 6
Wood duck	5	2	2 ± 1	1 ± 0
White-winged scoter	0	2		5 ± 1
Mute swan	5	9	64 ± 76	20 ± 16
Whistling swan	5	2	56 ± 54	2 ± 1
Canada goose	16	12	130 ± 154	110 ± 128
Ring-necked duck	2	2	4 ± 4	1 ± 0
Oldsquaw	1	0	2	
Tufted duck	1		1	

[a]Number of censuses in which the species was observed.

same in 1980 and 1981, with the exception of two areas north and northwest of Grosse Ile which were extensively used by canvasback and scaup in 1980, but rarely used by any waterfowl in 1981 (Figure 25). The extreme NW section of Lake Erie (south of Horse Is. toward Pt. Mouilee) was used by many diving ducks during the cold weather of January and early February, 1981. This area was not monitored during the preceding winter, but aerial surveys indicate it was also an important concentration area in 1980.

Comparison of Ground and Aerial Surveys

In general, aerial survey totals for the river were lower than ground counts. There was a marked exception to this in March of 1980 when the aerial count was nearly twice the ground count (Figure 24). The reason for this large disparity is not known, especially since the ground and aerial surveys were made on the same date. The regression between ground and aerial surveys indicates low predictive value if all eight surveys are included in the data set ($r^2 = 0.635$). But if the March 1980 survey is excluded, a highly significant relationship is evident ($r^2 = 0.988$, $Y = 26.3 + 0.45 X$, where Y = aerial estimate, X = ground count). This lends credibility to both techniques and in particular to the use of aerial data for comparisons concerning other areas on the Upper Great Lakes.

The comparison of species abundances indicated that the two techniques did not yield the same results. Examination of the rankings shows that, while the most abundant species were generally of the same rank with both techniques, one or two species were usually quite different. Most commonly there were major differences regarding scaup spp. and common goldeneye. The ground counts almost always had higher relative abundance for these two species. In contrast, the common merganser was usually more abundant in the aerial surveys. This suggests that there may have been confusion of mergansers and goldeneye at times. The reason for the lack of scaup sightings on aerial counts is not apparent, but they usually were clumped in one or two areas and thus could have easily been overlooked. The comparison of relative spatial use of the river indicates that, with no exception, the two techniques yielded the same results, i.e., the three major areas of the river were ranked the same in terms of relative abundance on each survey.

Activity - Location Effects With Waterfowl. Observations of scaup spp. and goldeneye at three locations, Mud Island, E. Grosse Ile, and the toll bridge showed that there were site-specific differences in feeding activity (Table 22). This further substantiates the hypothesis that the river system is a mosaic of resource patches, with certain areas better for feeding (toll bridge), but others better for roosting, displaying, etc.

The relationships of other variables on waterfowl activity (time of day, temperature) are illustrated in appendix D.

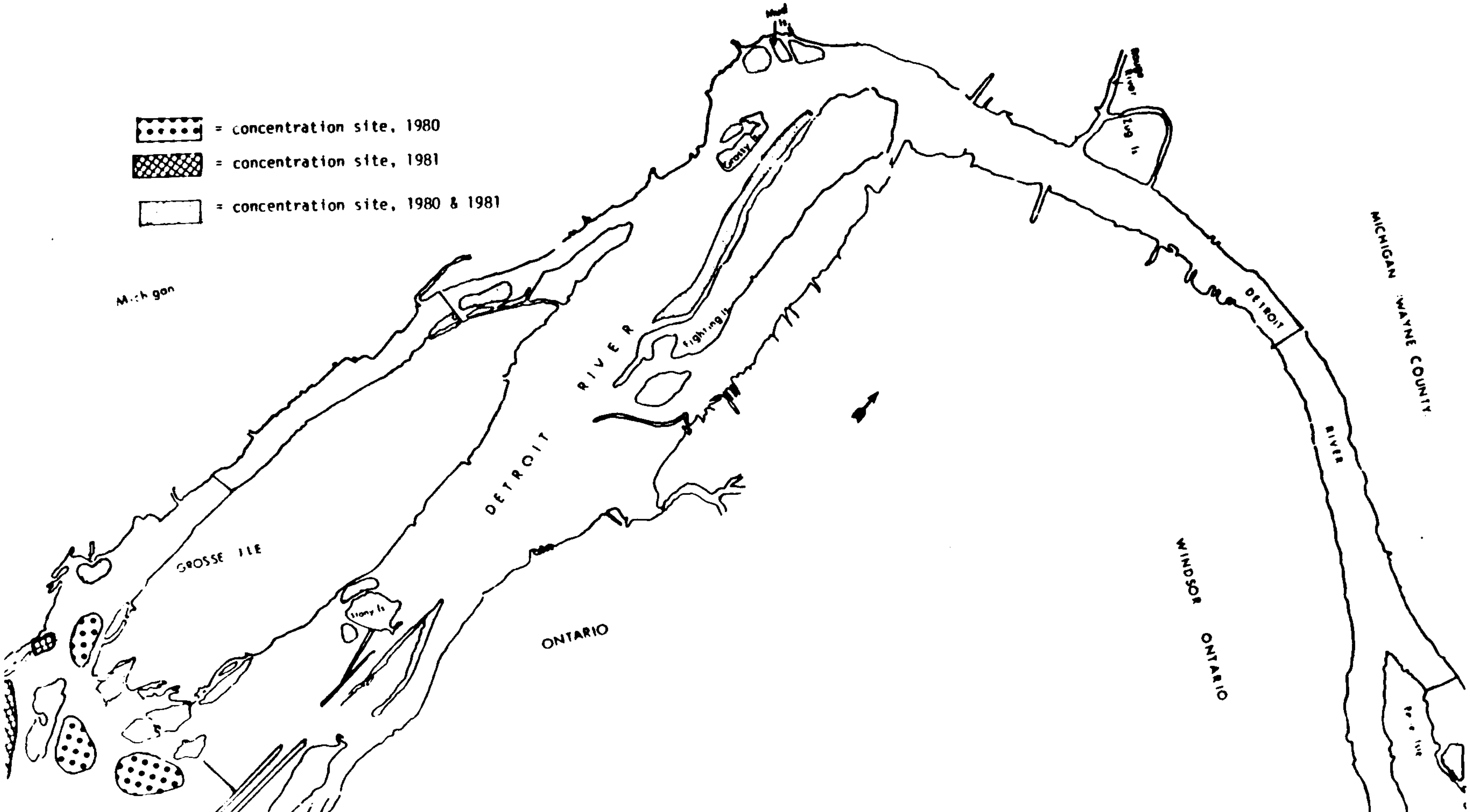


Figure 25. Concentration patterns of wintering waterfowl on the Detroit River, 1980 and 1981 (University of Michigan).

Table 22. Frequency of Feeding Behavior at Three Locations, Detroit River, Jan-March 1981[h].

Site	Species	N	% feeding Males	Females	Combined
E. Grosse Isle	Goldeneye	23	45	52	48[a]
Mud Island	Goldeneye	5	49	42	45[ab]
	Scaup	22	25	29	27[dg]
Toll bridge	Goldeneye	11	57	60	59[c]
	Scaup	11	62	68	64[e]
Horse Island	Scaup	3	34	26	27[fg]

[a-g] Statistical tests (ANOVA) between areas, for each species. If areas have letter in common, there is no significant difference ($p > 0.05$) between feeding frequency. If not letter in common there was a significant difference.

[h] N = Number of 1/2 h periods.

Summary of Winter Bird Distribution Studies (Unit 1)

The winter bird distribution of selected "waterbird" species on the Upper Great Lakes was examined by reviewing historical information and by collecting original data through field studies conducted during the winters of 1979-80 and 1980-81. The field studies included bimonthly aerial surveys of most harbors and selected shoreline areas of the Upper Great Lakes, weekly ground surveys of the Detroit River, and monthly ground surveys of shoreline transects scattered throughout the Great Lakes.

Our work indicates that most major winter waterbird concentrations occur in areas of direct or indirect human impact (e.g., open water at power plant sites and harbors). The major waterfowl use areas were the Detroit-St. Clair System, the Milwaukee harbor, the J. C. Weadock power plant at Bay City, Michigan, and the Bay Beach Park Wildlife Refuge and associated Fox River at Green Bay, Wisconsin. Areas of moderate use were Port Washingtin and Racine, Wisconsin, the St. Mary's River, and Muskegon and Traverse City, Michigan. Major gull populations were found at Milwaukee, Muskegon, and Detroit. The Detroit-St. Clair area is undoubtedly the most important overwintering site on all of the Upper Great Lakes due to the relatively high numbers (tens of thousands) and species which use the area (e.g., canvasback). Total waterbird numbers per survey ranged from 10,000 to nearly 40,000, and up to 87% of these were observed in the Detroit-St. Clair area. The major concentration sites were the same both years of our study.

The waterfowl species seen in large concentrations included, in descending order of abundance: canvasback, redhead, scaup spp., oldsquaw, mallard, common merganser, and common goldeneye. Only two gull species, the herring gull and ring-billed gull, occurred in significant numbers.

The number of birds using near-shore waters was low ($<$ 1.0 birds/km) and, with the exception of those areas which had 100% ice cover, did not appear to be affected by the amount of open water present. The dominant species were the common goldeneye, common merganser, and oldsquaw. These birds were generally seen in small scattered groups throughout the lakes, although oldsquaw often occurred in flocks of 50 to 100 birds. Areas of total ice cover were essentially unused.

It appears that the overwintering populations of at least some species vary appreciably from year to year. Early winter weather is an important factor in this regard. Mild weather during this period can result in significantly higher winter populations of species such as the canvasback and redhead. Total waterfowl populations on the Detroit River have varied from 10,000 to nearly 30,000 in recent years, paralleling the harshness of early winter weather.

Waterfowl populations on the Detroit River during the winters of 1979-80 and 1980-81 averaged nearly 12,000 and 4500 individuals, respectively. This difference reflects the relative mildness of early winter in 1979-80. The predominant species, in descending order of abundance, were canvasback, redhead, goldeneye, common merganser and *Anas* spp. All but the *Anas* spp. had significantly higher ($p \leq 0.05$) populations in 1979-80.

Waterfowl using the river congregated at specific sites. With few exceptions these were the same both years and were located in the lower half of the river from Gibralter to Ecorse. Only one species, the canvasback, seemed to relocate because of weather conditions. This species appeared to move from regular use areas to the east side of Grassy Island when subjected to strong (> 25 kph) winds. Navigation channels were almost never used.

BENTHOS AND FOOD HABITS - DETROIT RIVER WATERFOWL (STUDY UNIT 2)

Methods

Benthos analyses. Benthic organisms were collected on the lower Detroit River at two month intervals between November 1979 and May 1981. An effort was made to select sampling sites that had a history of waterfowl use. Three site catagories were selected to evaluate the effects of winter shipping on benthic organisms. Two sites were selected within each of the following categories: 1) ice free, adjacent to winter ship channels (sites 5,6), 2) ice free without winter shipping but adjacent to channels (sites 1,2); 3) frozen during winter (sites 3,4). The location of these sites is shown in Figure 26.

Within each of the six sites, sampling stations were selected at depths of 2 m and 4.5 m (± 0.5 m). Three replicates were collected within each site at each depth. Samples were randomly located within each site at the onset of sampling, and with one exception, were used throughout the remainder of the study. The exception was site 2 which was moved in January 1980 to increase sampling success and to reduce the risk of extremely fast currents capsizing the boat while sampling. This sampling scheme thus included six sites, two depth stations at each site, three grabs at each depth for nine of the ten sampling periods. During January 1981, only two grabs per station were taken at sites 3, 4, 5 and 6 instead of the usual three because of adverse weather conditions. Winter sampling periods included January and March, summer samples were taken in May and July, and fall samples were taken in September and November.

Samples were collected using a full ponar grab sampler (Mozley and Howmiller 1977). The chamber of the ponar grab is equivalent to 0.055 m^2. A conversion factor of 18.9 was used to convert numbers and weights of animals present to number/m^2 or mg/m^2. Contents from the ponar were washed through a 0.5 mm mesh net to concentrate animals and remove excess sediment and debris. Concentrated samples were stored in labeled quart Mason jars, and preserved with carbonate-buffered, 4% formaldehyde solution.

Organisms were further separated from substrate residues in the laboratory by vigorously stirring the sample and decanting off the slurry into a 0.5 mm gauge screen. This procedure was repeated until there was no evidence of benthic organisms in the sample when observed under a dissecting microscope. Samples with a large number of oligochaetes were subsampled using a Folsom planktonic splitter, and conversion factors were altered to make these samples equivalent to those not subsampled.

Invertebrates were sorted and identified to major taxa following Pennak (1978) and counted to determine density (individuals/m^2). Sorted samples were subsequently placed in a drying oven at 60°C for 24 hours and then dessicated and cooled to room temperature over a 24 hour period in a bell jar containing anhydrous calcium sulfate. Dry weights were measured to the nearest 0.001 mg.

Each taxon of benthic macroinvertebrates from each site for a particular depth was tested for normality using the chi-square test statistic. Equality of variances was tested, and skewness and kurtosis were measured for each taxon at the six sites for each depth using the formulae in Cooley and Lohnes (1971).

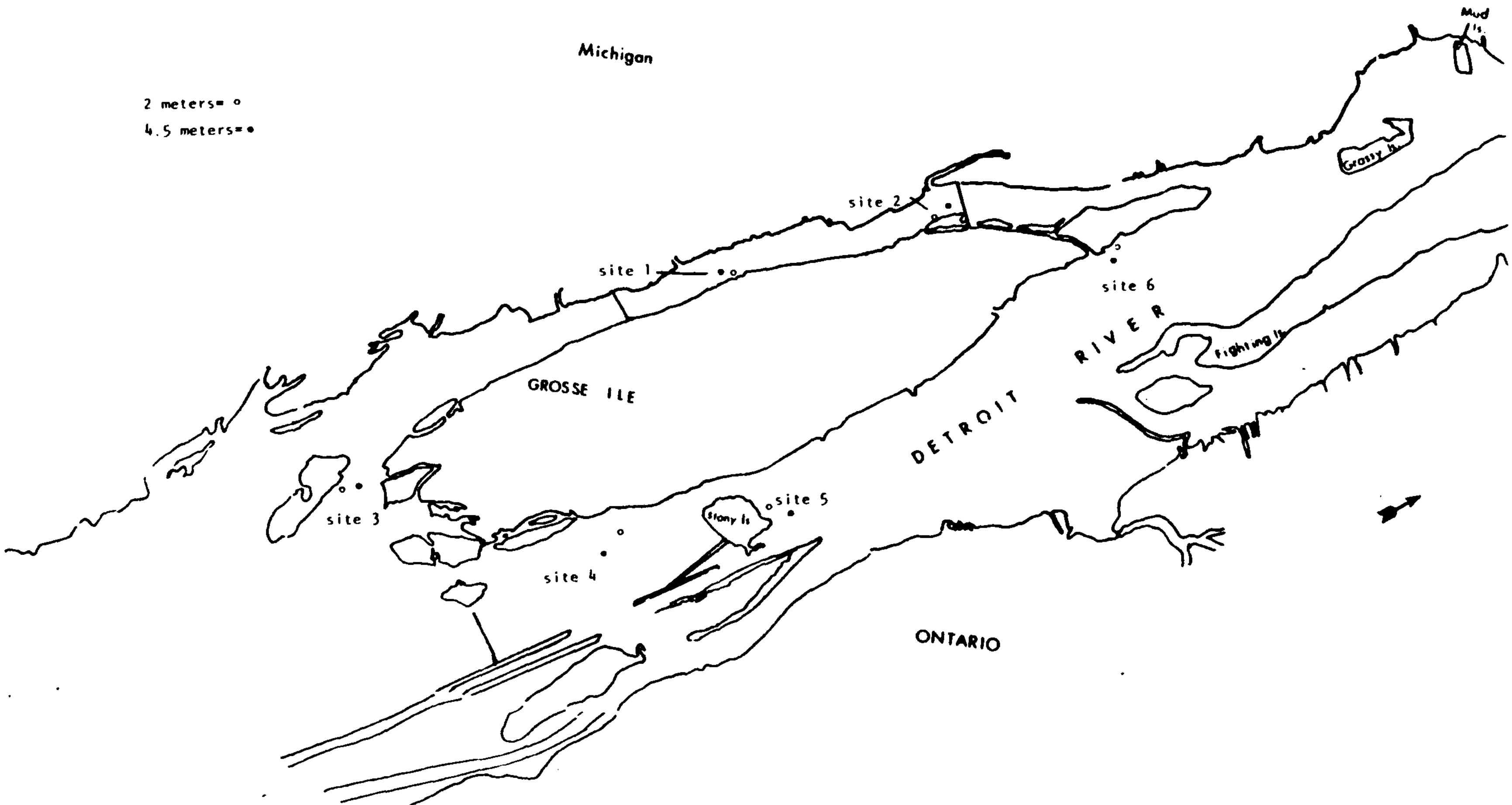


Figure 26. Location of the six sites used for benthos sampling, 1979-1981 (Univ. of Michigan).

Analysis for each taxon and for total animals indicated that none of the benthic organisms could be considered normally distributed, therefore non-parametric tests were used for the analyses of benthos data.

Either the median test or the Kruskal-Wallis test for multiple sample comparisons were used to determine differences in density and biomass of organisms between sampling sites at 2 m and 4.5 m depths. Kruskal-Wallis tests were used when comparing density or biomass of oligochaetes between sites, depths, or seasons because of its high power relative to the median test. However, all macroinvertebrate taxa other than oligochaetes occurred either in low numbers or sporadically at all depths and sites, therefore it was necessary to use the median test to determine differences between sites, depths, and sampling periods (Cooley and Lohnes 1971). If the Kruskal-Wallis multiple sample comparisons test, or the median test indicated significant differences among sites, depths or sampling periods, analysis of variance test was used to compare strata in a pairwise fashion to determine which regions at a particular site, depth, or sampling period were dissimilar.

At each benthos sampling station, a single substrate sample was taken to evaluate the characteristics of the substrate. These samples were analyzed for particle size by first sieving out coarse gravel (particles > 2 mm). The percent coarse gravel was calculated as a percent of the total weight of the sample. Fifty grams of the substrate that passed through the sieve were used to calculate the percent of sand, clay, and slit using the hydrometer method (Grigal 1973).

Food Habits Analysis. Food habits analyses were conducted on 53 common goldeneye, 56 greater scaup, and 60 lesser scaup. These species were chosen because they are common winter residents in the area and because they normally feed on benthos (Cottam 1939). Birds were collected with a shotgun in areas that were important foraging sites for wintering waterfowl. Decoys were used to increase collecting success. Weekly collections were made from January through March except when ice conditions precluded access to the river.

Initial handling of the ducks that had been collected followed closely the procedures described by Swanson and Bartonek (1970). Immediately following collection, the upper digestive tract was removed and its contents placed in jars containing 80% alcohol to minimize post-mortem digestion. Food items were identified using guides by Martin and Barkley (1961), Fassett (1975), and Pennak (1978), and measured volumetrically according to the methods of Drobney (1977). The aggregate percent volume and frequency of occurrence were calculated for all food items within each of the three species of ducks collected.

Other measurements taken on each duck collected included the weights of the major internal organs, total body weight, and the defeathered, evicerated carcass weight (DEC wt.). The DEC weight did not include the weight of the head, feet, or internal organs.

The chi-square test for normality and tests for kurtosis and skewness showed total weights and DEC weights to be normally distributed. The DEC weights of each species and sex were grouped into three time periods for analysis. These were: January, February (first three weeks of February), and February-March (includes ducks collected the last week of February).

Birds collected the last week of February were grouped with the birds collected in March to decrease the variability in DEC weights within each time period. Data were evaluated using analysis of variance with Scheffe's allowance (Snedecor and Cochran 1967), and tests of hypotheses were made at the 95% confidence level.

Results and Discussion - Benthos

Depth Comparisons. The density of oligochaetes was significantly lower at 4.5 m than at 2 m. This relationship was consistent for each of the six sites (Table 23), for all seasons (Table 24), and during winter only (Table 25). Substrates at 4.5 m contained at least 3.3 times more coarse gravel (particle size > 2 mm) than the substrates at 2 m. We believe oligochaetes are being limited by the higher percentage of coarse gravel in the substrate at deep water sites. Coarse substrate has been shown to limit oligochaetes in lake systems (Mozley and Garcia 1972, Mozley and Howmiller 1977, Winnel and Jude 1978). However, these studies also indicated that the density of organisms was reduced at shallow depths due to the eroding affects of wave action which in lake systems is greater near shore.

In river systems, substrate characteristics are primarily influenced by current velocity (Hynes 1970), which is greater in the center of the channel and decreases progressively towards the shore (Whitten 1975). Rapidly flowing water resuspends small particulates, leaving behind coarse particles.

In this study, deep water sites were located either adjacent to shipping channels or near the center of the river where current velocity is likely to be highest, whereas 2 m sites were located near the shore where the velocity is probably lower. The higher percentage of coarse gravel at 4.5 m depths relative to 2 m depths supports the assertion that velocity was greater at deep water stations than at shallow water stations (Table 26).

It seems that current velocity influences oligochaete density indirectly by altering the characteristics of substrate. Rapid currents at 4.5 m apparently wash away fine soil particles, creating an unfavorable environment for soft-bodied oligochaetes. Two meter depths were protected because of their proximity to shore and were not as susceptible to the eroding effects of current. Shallow water stations therefore provided a more favorable benthic habitat for oligochaetes.

No significant differences were found between sites or depths for taxa other than oligochaetes. However, the scarcity and high variability of these taxa in benthos samples obscured possible relationships that density may have had with site or depth parameters. Many of these less abundant taxa were selected by wintering waterfowl and will be discussed in relation to the food habits of waterfowl in a later section.

Sampling Site Comparisons. At 2 m, macroinvertebrate density did not differ significantly between the three categories of sites. Therefore, proximity of shallow water sites to winter shipping channels did not seem to influence the density of benthic organisms, however shipping did not occur during the time that this study was being conducted.

Table 23. Oligochaete Density (individuals/m^2) for Each Sampling Site, 2 m and 4.5 m Depths.

	Site											
	1[a]		2[a]		3[b]		4[b]		5[c]		6[c]	
	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE	mean	SE
2 meters	16891	5462	27008	8110	13965	3755	7644	2137	11373	3282	9609	2346
4.5 meters	392	160	1065	514	1559	475	941	175	827	502	2306	691

[a]Ice-freeze, no shipping channel nearby.
[b]Frozen.
[c]Ice-free, adjacent to channels.

Table 24. Mean Density and Standard Error for Each Macroinvertebrate Taxa for All 2 m and 4.5 m Sites (All Periods).

Taxa	Depth			
	2 meters		4.5 meters	
	Mean	SE	Mean	SE
Oligochaeta	14445	1867.3	1181	173.9
Polychaeta	219	158.9	174	79.0
Copepoda	10	7.1	3	1.3
Isopoda				
Asellus sp.	1	1.0	0.4	0.4
Amphipoda				
Gammarus sp.	72	30.1	6	1.3
Hydracarina	10	3.5	2	0.9
Insecta				
Ephemeroptera				
Baetisca carolina	1	0.4	3	0.9
Hexegenia sp.	1	0.4	0.2	0.2
Trichoptera	1	0.9	3	0.8
Odonata				
dragonfly	3	1.9	-	-
damselfly	2	1.7	-	-
Coleoptera	3	2.0	0.1	0.1
Diptera				
Chironomidae	135	24.0	10	2.5
Culicidae	4	2.2	1	0.4
other	2	1.8	-	-
Gastropoda				
Ancylidae	159	97	7	2.5
Amnicola limosa	21	6.2	1	0.5
Valvata sp.	55	37.0	1	0.9
Physa sp.	5	1.8	1	0.3
Gyraulus sp.	2	1.1	-	-
Pleuroceridae	0.3	0.2	-	-
Viviparidae	2	1.8	-	-
Pelecypoda				
Sphaeriidae	29	11.9	26	10.4
Nematoda	22	8.6	8	5.3
Arachnid	-	-	0.4	0.4

Table 25. Mean Densities of All Macroinvertebrate Taxa at 2 m and 4.5 m (for All Sites) During the Winters of 1980 and 1981.

2 meters			4.5 meters		
Taxa	Mean	SE	Taxa	Mean	SE
Oligochaeta	10321	1477.5	Oligochaeta	1105	259.8
Chironomidae	133	48.7	Polychaeta	145	96.9
Gastropoda			Pelecypoda		
Ancylidae	123	67.1	Spheridae	52	25.9
Hirundinidae	34	10.3	Nematoda	19	13.3
Amphipoda			Diptera		
Gammarus sp.	27	9.0	Chironomidae	12	3.1
Gastropoda			Gastropoda		
Amnicola limosa	22	9.8	Ancylidae	7	3.0
Gastropoda					
Valvata sp.	17.2	8.5	Copepoda	6	2.1
Pelecypoda			Amphipoda		
Sphaeriidae	13	5.5	_Gammarus_ sp.	5	1.7
Hydracarina	10	3.7	Hirundinidae	5	2.5
Copepoda	6	2.9	Hydracarina	5	2.3
Gastropoda			Ephemeroptera		
Physa sp.	3	2.5	_Baetisca carolina_	3	1.6
Nematoda	3	2.4	Trichoptera	3	1.6
			Gastropoda		
Trichoptera	3	2.2	_Valvata_ sp.	2	2.2
			Gastropoda		
Coleoptera	3	2.2	_Amnicola limosa_	1	1.1
Gastropoda					
Gyraulus sp.	2	2.2	-	-	-

Table 25 (concluded).

2 meters			4.5 meters		
Taxa	Mean	SE	Taxa	Mean	SE
Ephemeroptera					
Sphemera sp.	+1	1.3	-	-	-
Baetisca carolina	1	1.1	-	-	-
Hexegenia sp.	1	0.8	-	-	-
Isopoda					
Asellus sp.	1	1.1	-	-	-
Gastropoda					
Pleuroceridae	1	1.1	-	-	-
Diptera					
Culicidae	1	1.1	-	-	-
Gastropoda					
Viviparidae	0.3	0.3	-	-	-

Table 26. Percent Coarse Gravel (Particle Size > 2 mm) of the Total Substrate Sample at Each Station.

Depth(m)	Site 1	2	3	4	5	6
2	3.70	3.20	3.60	1.20	3.50	1.10
4.5	16.10	32.40	11.80	12.60	17.10	42.55

In contrast to 2 m sites, there were significant differences in oligochaete densities between sites at 4.5 m. Site 1 had a significantly lower density of oligochaetes than all other sites, and site 6 had a significantly higher oligochaete density than all other sites (Table 23).

These differences between sites at 4.5 m could be attributed to substrate differences at site 1 and site 6 when compared to other sites. At site 1, the percent sand of the soil component was 24% (Table 27). The mean for all other sites was only 10.8%. Coarse sand could be limiting oligochaetes for the same reasons discussed previously. Site 6 had the highest densities of oligochaestes and was the only site without sand as part of its soil component. The absence of sand could allow greater survivorship of oligochaetes.

There was one exception to the above relationship between oligochaete density and substrate composition. The exception was site 3, which had the highest sand component (26%), yet oligochaete density was significantly higher at site 3 than at site 1 (Table 23). However, oligochaete density at site 3 was still significantly lower than at site 6.

Deep-water stations adjacent to shipping channels indicated both lower (site 1), and higher (site 6) oligochaete densities relative to the other sites (non-significant however, $F = 3.56$, $p = 0.06$ for both comparisons). It is likely that oligochaete density at 4.5 m was not influenced by the proximity of the site to a shipping channel during this study. We must presume that the differences observed between sites are related more to substrate type or current velocity rather than the proximity of sites to shipping channels.

Seasonal Trends. The density and biomass of oligochaetes showed a pronounced peak during summer sampling periods at 2 m depths, however this pattern was not evident at 4.5 m depths (Fig. 27). Statistical analyses indicated no significant difference in density or biomass of oligochaetes between fall and winter sampling periods.

At 2 m depths the highest mean oligochaete densities were found during May and July. Densities did not differ significantly between these two months in 1980. However, both had significantly higher densities than all other fall and winter sampling periods. In 1980, the density in March was only marginally lower than in May ($F = 3.72$, $p = 0.06$) and July ($F = 3.14$, $p = 0.08$). It is interesting to note that the May 1981 period did not exhibit the same increase in density as shown in 1980. The lower density observed in May 1981 is discussed later.

Analysis of oligochaete biomass measurements from 2 m depths indicated that the average in May of 1981 was significantly higher than the preceding fall and winter. May and July of 1980 also had significantly higher means than January 1981 ($F = 12.64$, $p = 0.0$, $F = 11.55$, $p = 0.0$, respectively).

Aston (1973) and Hiltunen (1967) found that warming water temperature stimulates maturation of oligochaetes in the family Tubificidae which results in reproduction and increases in their populations some weeks or months later. The relatively higher biomass and lower density in May of 1981 could indicate that oligochaete cocoons had not yet been deposited, but were forming in the

Table 27. Percent Soil Component (Particle Size < 2 mm) at All Stations.

Soil comp.	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6	
	2m	4.5m	2m	4.5m	2m	4.5m	2m	4.5m	2m	4.5m	2m	4.5m
% sand	40	24	42	02	28	26	26	14	42	22	22	00
% clay	08	04	20	02	02	06	04	04	14	02	06	18
% silt	52	72	38	92	70	68	70	82	44	76	72	82

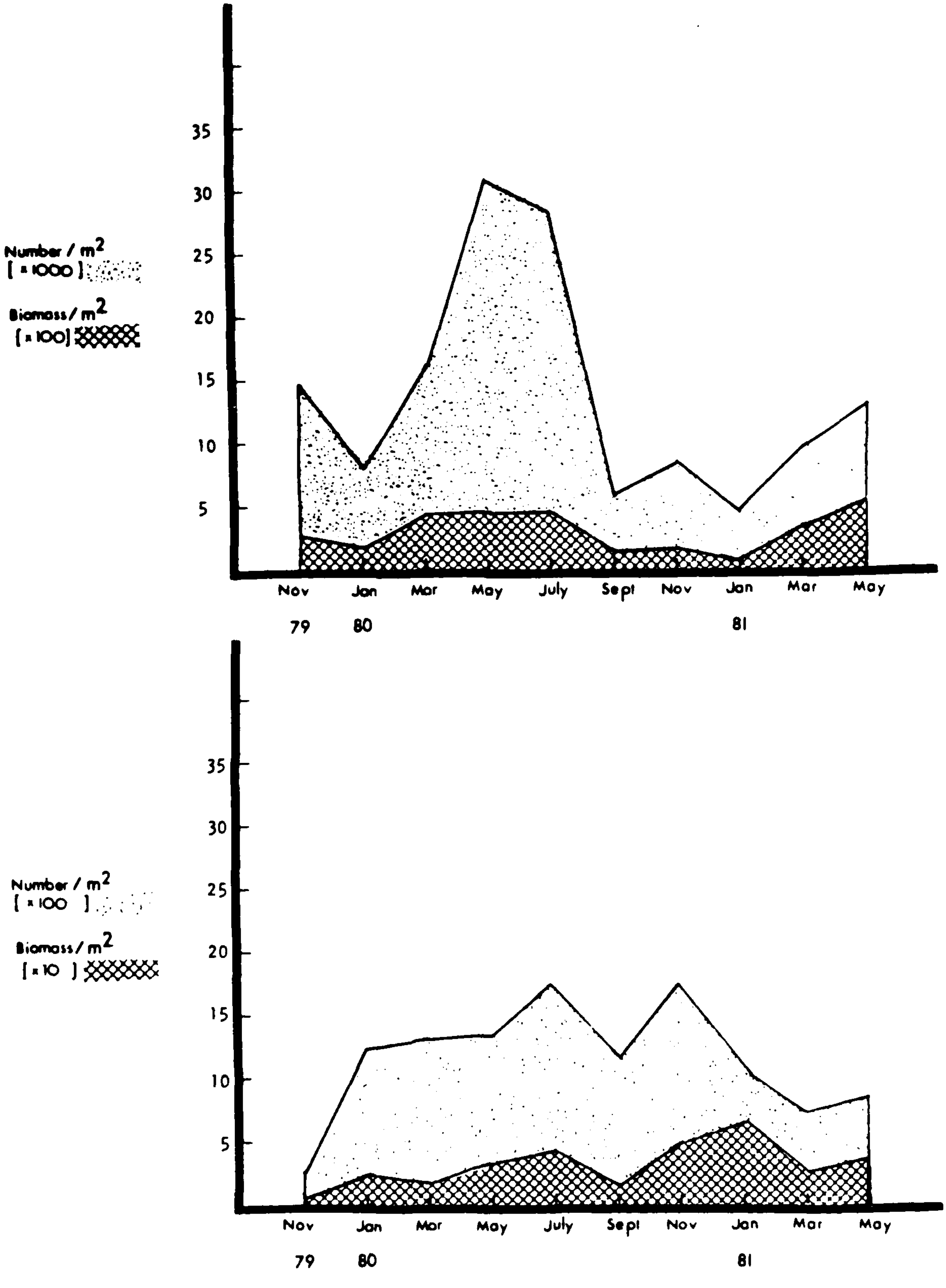


Figure 27. Oligochaete densities at 2m for 10 sampling periods, 1979-1981.

adults. The fact that the May 1981 samples were taken much earlier in the month than in 1980 lends credence to this hypothesis. Pennak (1978) states that syngamic reproduction seldom occurs before July, but Aston's studies show reproduction in tubificids is largely a function of water temperature. It seems probable that warm water effluents from industrial sites along the Detroit River causes water temperature to reach the critical temperature for reproduction earlier in the year, thereby inducing earlier laying.

There were no significant seasonal trends in taxa other than oligochaetes. The lack of significant differences in these taxa was probably due to the scarcity of these benthic organisms, and the large amount of variability between benthic samples. Patchy distribution patterns often occur in benthic organisms (Whitten 1975) and result in extremely high variances between samples for each taxon. However, Whitten (1972) has shown that growth and survivorship of macroinvertebrates from a temperate zone stream is at a minimum during December, January, and February. Hynes (1970) also states that during winter, growth and recruitment of most macroinvertebrates declines. It is possible that the extremely high variation observed for taxa other than oligochaetes obscured seasonal trends. It is our belief that taxa densities of other macroinvertebrates probably also declined during winter, although these differences were not detectable statistically.

In summary, our results show a building up of oligochaete biomass in early spring beginning in May or slightly earlier. Decreases in number and biomass occur in the fall as organisms die and recruitment is reduced. High variability in density for taxa other than oligochaetes tends to obscure any seasonal fluctuations that may occur.

<u>Comparison to St. Mary's River Studies</u>. Studies similar in scope to the present work have been conducted on the St. Mary's River. Poe et al. (1979) examined the effects of winter vessel passage on benthic macroinvertebrate populations in areas from near 0 m to approximately 200 m from the shipping channel and at depths ranging from 1 m to 3 m. They did not demonstrate significant impact, but a small sample size essentially precluded any possibility of doing so. They did however indicate that ship passage resulted in increased drift, and this same phenomonon would seem likely to occur as a result of winter traffic on the Detroit River. Liston et al. (1980) also examined benthic populations on the St. Mary's River, but did not directly address shipping impact. This study did demonstrate that significantly lower macroinvertebrate populations existed in the shipping channel, but these results are probably related to depth and sediment difference (this report) more than effects of shipping per se.

The above studies do point out a fundamental difference in the Detroit and St. Mary's system. In contrast to the almost complete dominance of Tubificidae in the Detroit River, the benthos of the St. Mary's River (other than near Sault Ste. Marie) is more diverse and tends to be dominated by Chironomidae. This reflects a major difference in water quality. The Detroit River is a highly polluted aquatic system, and, as is often the case under such conditions, tubificids are predominant and diversity low (Hynes 1963). Further comparison of the two areas would require a more detailed examination of current velocities and sediment composition on the St. Mary's River sites.

Results and Discussion - Food Habits

A total of 169 birds were collected during the winters of 1980 and 1981, with 77% containing a sufficient amount of food in their upper digestive tracts for use in food habits analysis. The usable sample included 47 greater scaup (18 females and 29 males), 44 lesser scaup (17 females and 27 males), and 39 common goldeneye (19 females and 20 males).

The results of the food habits analysis are summarized by species and sex in Tables 28, 29, and 30. Data in these tables are presented by aggregate percent volume and frequency of occurrence. The three species of ducks contained a combined total of 30 taxa of foods. This total included 10 taxa of plant foods and 20 taxa of animal foods.

The diets of the three species of ducks were more similar with respect to the taxa of plant foods consumed than animal foods. Seventy percent of all plant taxa were found in all three species of ducks as compared to only 40% of the animal taxa. It should also be noted that those taxa of both plants and animals that were not found in all three species of ducks generally occurred relatively infrequently in the diets of those species in which they were found. The primary exceptions were chironomids which were found in 5 goldeneye and pleurocerids which were found in 11 greater scaup and 5 lesser scaup.

An evaluation of the top ranked taxa of foods support two important points regarding the winter food habits of the three species of waterfowl studied: 1) relatively few taxa comprised the bulk of their diet; and 2) important taxa of foods were quite similar in all three species.

The sum of the aggregate percent figures for the first seven foods listed for each species shows that these foods account for more than 80% of the diets of all species. Hence, less than one-third of the taxa comprise nearly all of the diet of these species.

In support of the second point, we find that the seven top-ranked foods in all three species contain only 11 food types. This low number indicates that there is considerable overlap in the food items that were selected by the three species of ducks. Four of these foods (*Vallisneria* sp., *Potamogeton* sp., Oligochaeta, and plant fragments), ranked among the top seven in all three species. Pleurocerids and minnows of the genus *Notropis* sp. ranked among the top seven foods for two of the three species. The other five food types occurred among the seven top-ranked foods in only one of the three species, but often occupied a lower rank in one or both of the other species of ducks.

Plant vs. Animal Foods. Plant matter constituted a substantial fraction of the esophageal contents of all three species of ducks (Table 31). The percent of plant food in the diet was 72.1%, 81.2%, and 64.8% for greater scaup, lesser scaup, and goldeneye, respectively. These results suggest that plant foods were considerably more important to wintering waterfowl than animal foods.

We think, however, that the importance of plant matter was erroneously inflated by the category "plant fragments." Nearly 60% of all ducks used

Table 28. Esophageal Contents of Common Goldeneyes[a] Collected During the Winters of 1980 and 1981 on The Detroit River.

Food item	Aggregate %		Occurrence %	
	♀	♂	♀	♂
Vallisneria sp.	30.70	43.25	52.60	60
Oligochaeta	12.60	6.29	31.58	15
Plant fragments	11.43	22.27	52.60	40
Decapoda	9.44	5.18	15.79	10
Unidentified fish	8.21	4.79	5.26	5
Potamogeton sp.	6.61	4.10	26.32	15
Chara sp.	6.13	-	10.53	-
Notropis sp.	5.17	4.69	5.26	5
Gammarus sp.	3.67	0.22	15.79	5
Chironomidae	2.55	-	26.31	-
Scirpus sp.	.85	2.10	10.53	15
Asellus sp.	.75	-	5.26	-
Gyraulus sp.	.48	-	10.53	-
Hirundinea	.38	-	5.26	-
Arachnida	.37	-	5.26	-
Coleoptera	.37	-	5.26	-
Ephemeroptera	.10	4.49	5.26	5
Moss	.10	-	5.26	-
Unidentified seeds	.07	0.94	10.53	15
Najas sp.	.05	-	5.26	-
Physa sp.	.05	-	5.26	-
Bryozoans	-	0.71		5
Diptera	-	0.66		5
Amnicola sp.	-	0.04		5

[a]Females, n = 19, males, n = 20.

Table 29. Esophageal Contents of Lesser Scaup[a] Collected During the Winters of 1980 and 1981 on the Detroit River.

Food item	Aggregate % ♂	Aggregate % ♀	Occurrence % ♂	Occurrence % ♀
Plant fragments	44.68	41.94	63.00	64.71
Vallisneria sp.	23.29	14.11	44.40	35.29
Potamogeton sp.	6.60	-	14.80	-
Oligochaeta	6.49	17.51	11.10	23.50
Scirpus sp.	5.89	-	22.20	-
Pleuroceridae	3.91	6.61	11.10	11.76
Algae	2.96	1.76	3.70	5.88
Unidentified seeds	1.98	12.01	22.20	23.50
Chara sp.	1.42	-	7.40	-
Bryozoan	.93	-	7.40	-
Hirundinidae	.50	1.40	3.70	11.76
Najas sp.	.47	.84	7.40	5.88
Egg mass	.20	-	7.40	-
Gammarus sp.	.14	-	3.70	-
Viviparidae	.14	-	3.70	-
Physa sp.	.10	-	3.70	-
Sphaeriidae	.10	-	3.70	-
Amnicola sp.	.07	-	3.70	-
Gyraulus sp.	.07	-	3.70	-
Asellus sp.	.03	-	3.70	-
Trichoptera	-	4.16	-	5.88
Polygonum sp.	-	.91	-	5.88

[a]Females, n = 17, males, n = 27.

Table 30. Esophageal Contents of Greater Scaup[a] Collected During the Winters of 1980 and 1981 on the Detroit River.

Food item	Aggregate % ♂	Aggregate % ♀	Occurrence % ♂	Occurrence % ♀
Plant fragments	36.33	27.83	72.41	61.10
Vallisneria sp.	34.71	23.84	51.72	33.30
Pleuroceridae	11.11	19.28	20.69	27.80
Notropis sp.	3.45	-	3.45	-
Oligochaeta	3.39	10.90	6.90	27.80
Hirundinidae	2.26	-	6.90	-
Bryozoa	2.14	-	6.90	-
Unidentified seeds	1.15	-	6.90	-
Potamogeton sp.	1.13	5.76	10.34	16.70
Chara sp.	.79	-	6.90	-
Physa sp.	.72	.31	6.90	5.60
Diptera	.67	-	3.45	-
Myriophyllum sp.	.37	-	6.90	-
Najas sp.	.58	-	6.90	-
Arachnida	.31	-	3.45	-
Scirpus sp.	.27	.37	6.90	11.10
Gammarus sp.	.25	-	3.45	-
Asellus sp.	.20	.28	3.45	-
Sphaeriidae	.05	-	3.45	5.60
Unidentified animal matter	.05	-	3.45	-
Egg mass	.02	.01	3.45	5.60
Algae	-	8.86	-	22.20
Gyraulus sp.	-	1.72	-	5.60
Amnicola sp.	-	.57	-	16.70
Lanaidae	-	.23	-	5.60

[a]Females, n = 18; males n = 29.

Table 31. Summary of the Aggregate Percent of Animal and Plant (in parenthesis) Foods in the Diets of Common Goldeneye, Greater Scaup and Lesser Scaup by Species and Sex.

Species	Male	Female	Overall
Common Goldeneye	27.3 (72.6)	44.0 (55.9)	35.6 (64.8)
Greater Scaup	24.6 (75.3)	33.1 (66.9)	27.9 (72.1)
Lesser Scaup	12.7 (87.3)	28.4 (71.6)	18.6 (81.6)

for food habits analysis contained small pieces of plant matter in their upper digestive tracts. Materials assigned to this category included small twigs, pieces of skeletonized leaves, and partially decomposed plant debris from the previous growing season. These items were included in our analysis because they were found in the esophagus. However, it is doubtful whether the ducks actually selected this material because of its low nutritional value. We strongly suspect that nearly all of this material was ingested incidentally while the ducks were foraging in the substrate for other foods. If the category "plant fragments" is excluded, the importance of plant and animal foods becomes more nearly equivalent.

Plant Foods. Wild celery (Vallisneria sp.) and pondweeds (Potamogeton sp.) were the most important plant foods consumed by the three species of ducks during winter. The high use of these foods probably reflects availability as well as preference. Both pondweeds and wild celery have long been regarded as important foods for a number of waterfowl species and have been found to be among the top-ranked plant foods for lesser scaup (Cottam 1939, Quay and Critcher 1962), greater scaup (Stewart 1962) and common goldeneye (Cottam 1939, Stewart 1962) during fall and/or winter in freshwater habitats. An aquatic plant survey conducted along the lower Detroit River (Hunt 1963) has shown that they are the two most abundant plants in our study area, suggesting that availability might also have had an important effect on use.

Various species of algae (Chara sp.), Scirpus sp., and seeds constituted a small proportion of the diet in one or more of the three species of ducks, but none exceeded 4% of the diet. The other plant taxa were ingested infrequently and accounted for less than 1% of the diet.

Animal Foods and Availability. Two points become evident when comparisons between food habits data and benthic samples are made. These points are: 1) food habits were related to the availability of these food items, and 2) the most important waterfowl animal foods were more available (had higher mean densities), at 2 m than at 4.5 m.

Oligochaetes in the family Tubificidae were found to be the most important animal food for all three species. During the winter sampling periods, oligochaetes (many of which were tubificids) were the only organism to occur in 100% of the samples. At 2 m, the mean density of oligochaetes was at least 77.6 times greater than the mean density of any other taxon (Table 25). Oligochaetes were by far the most abundant organism sampled and were also the most important animal food consumed by all three species. Oligochaetes were 9 times more abundant at 2 m (mean = $10321/m^2$) than at 4.5 m (mean = $1105/m^2$).

Although tubificids have not been previously reported as an important food of diving ducks, these findings support the points discussed previously. Selection is closely related to availability, and densities of important animal foods are greater at 2 m than at 4.5 m.

Reviews of previous food habits studies of common goldeneye, greater scaup, and lesser scaup in Bellrose (1980) suggest some general differences in the types of animal foods selected by these species, although considerable intraspecific variation resulting from habitat differences has also been found. In nearly all studies, clams have predominated in the diet of greater scaup. Lesser scaup appear to be more herbivorous than greater scaup, but when animal

foods are consumed, snails and clams predominate. Crustaceans, mollusks, insects, and fish have been found to be the most important animal foods in the diets of common goldeneye.

The high consumption of clams noted for all three species in other studies was not characteristic of the diet of ducks collected on the Detroit River. Benthos data indicated clams of the family Sphaeriidae were the only Pelecypoda available as a waterfowl food during both winters, and these clams were less abundant relative to oligochaetes, chironomids, leeches, amphipods, and many gastropods (Ancylidae, Amnicola sp., Valvata sp.) (Table 25). At 4.5 m clams were relatively abundant when compared to other taxa (e.g., gastropods, amphipods and chironomids). Spheriid clams were the only benthic organism found in the upper digestive tract that was more abundant at 4.5 m (mean = $52.6/m^2$) than at 2 m ($12.5/m^2$), however, only 3 individuals consumed spherrid clams. Sphaeriid clams are rarely larger than 10 mm (Pennak 1978), and it is probable that the increased energy needed to dive 4.5 m to feed on higher densities of clams, limited the use of these clams as a waterfowl food source. Therefore low availability at 2 m and the possible low caloric return of small spheriid clams at 4.5 m, seem to be the reasons for limited use of clams by waterfowl in our study.

In contrast to clams, gastropod taxa were well represented in the diets of all three species. Greater scaup contained six taxa while goldeneye and lesser scaup contained three and four taxa, respectively. Even though a wide range of taxa were consumed, only pleurocerids were ingested frequently enough and in sufficient volume to be considered an important food. Pleurocerids ranked high in the diets of both species of scaup, but were not found in goldeneye.

Neither decapods nor fish were found in the diets of birds collected during the winter of 1980, however, both became important in the diets of goldeneye during the cold early winter months of 1981. This change in food habits appears to have resulted from a loss of shallow water feeding sites due to increased ice cover. Fish were recovered from only one greater scaup, but were not found in lesser scaup. Other animal taxa constituted very small percentages of the aggregate percent volume for all three species.

Species/Sex Differences in Diet. Inspection of the percentages in Table 33 indicated that the percent of animal foods consumed might differ by species or sex. To determine if the observed differences were significant, statistical comparisons were made between species, between the sexes of a species, and between the same sexes of different species using Mann Whitney-U tests. The results of these tests showed a significant difference ($p < 0.05$) only between common goldeneye and lesser scaup. Differences did exist between greater and lesser scaup ($p = 0.08$) and males and female goldeneye ($p = 0.08$).

The lack of significant differences, despite widely differing means, is not particularly unusual for food habits data derived from esophageal contents. Except during times when food is plentiful and is therefore being ingested at a faster rate than it can be processed in the gizzard, the contents of the esophagus of an individual represent a short-term sample. Hence, individuals often contain either all animal foods or all plant foods depending upon the type of food that was being eaten just prior to being collected. The result

is high variance between individuals in the sample. This problem is magnified during times of food shortage because food is being processed almost as rapidly as it is ingested. Characteristics of the food itself (i.e., hardness and fiber content) also influence processing and passage rates (Swanson and Bartonek 1970).

Nearly all foods consumed by birds collected during this study were types that could be processed rapidly. Seeds, which normally require the most processing time (Swanson and Bartonek 1970) were rarely found in the ducks that we collected. The low volume of food found in the upper digestive tracts of most ducks in this study is therefore probably a reflection of the combined effects of rapid passage rates and low food availability. The low volume of food observed during visual inspections of the gizzard contents lends further support to this hypothesis.

In conclusion, it is important to point out that high variability in the percentages of plant and animal foods between individuals in a sample does not negate the validity or importance of the composite food habits results for a species.

Body Weight Changes. The defeathered evicerated carcass weights (DEC wt.) of male common goldeneye, female and male greater scaup, and male lesser scaup were significantly lower in February than in January (Fig. 28). We believe these changes in body weights could be due to metabolism of endogenous lipids necessitated by the combined effects of reduced food intake (resulting from lower food availability) and increased energy requirements (caused by lower ambient temperatures).

Oligochaetes were the most important animal food item consumed by all species of ducks collected. Results from benthos analyses showed a decline in oligochaete density during January at 2 m stations (Fig. 27). Although no benthos samples were taken during February, we believe declines observed in January for oligochaete density at 2 m probably continued during February. This assertion is supported by the results of Aston (1973) which show maturation and reproduction in oligochaetes occuring during periods of high water temperatures. Although water temperature was not measured, low ambient temperature and the presence of ice on the river during most of February probably limited oligochaete numbers during February. Low abundance of an important high-protein food resource during January and probably much of February could cause ducks to rely more heavily on their endogenous lipid reserves.

At 4.5 m stations, oligochaete density did not decline significantly during winter sampling periods. However these stations were significantly less productive than 2 m sites (Table 24), and wintering waterfowl used deep water areas for feeding less frequently. Even though the 4.5 m sites have sparse resources all year compared to 2 m sites, these may become the only sites available for feeding waterfowl if the shallow depths become frozen or blocked with ice.

Peterson and Ellarson (1977) attributed changes in body weights of oldsquaws wintering on Lake Michigan to decreased lipid levels. They found that the percent fat content in oldsquaws collected from gill nets during winter and

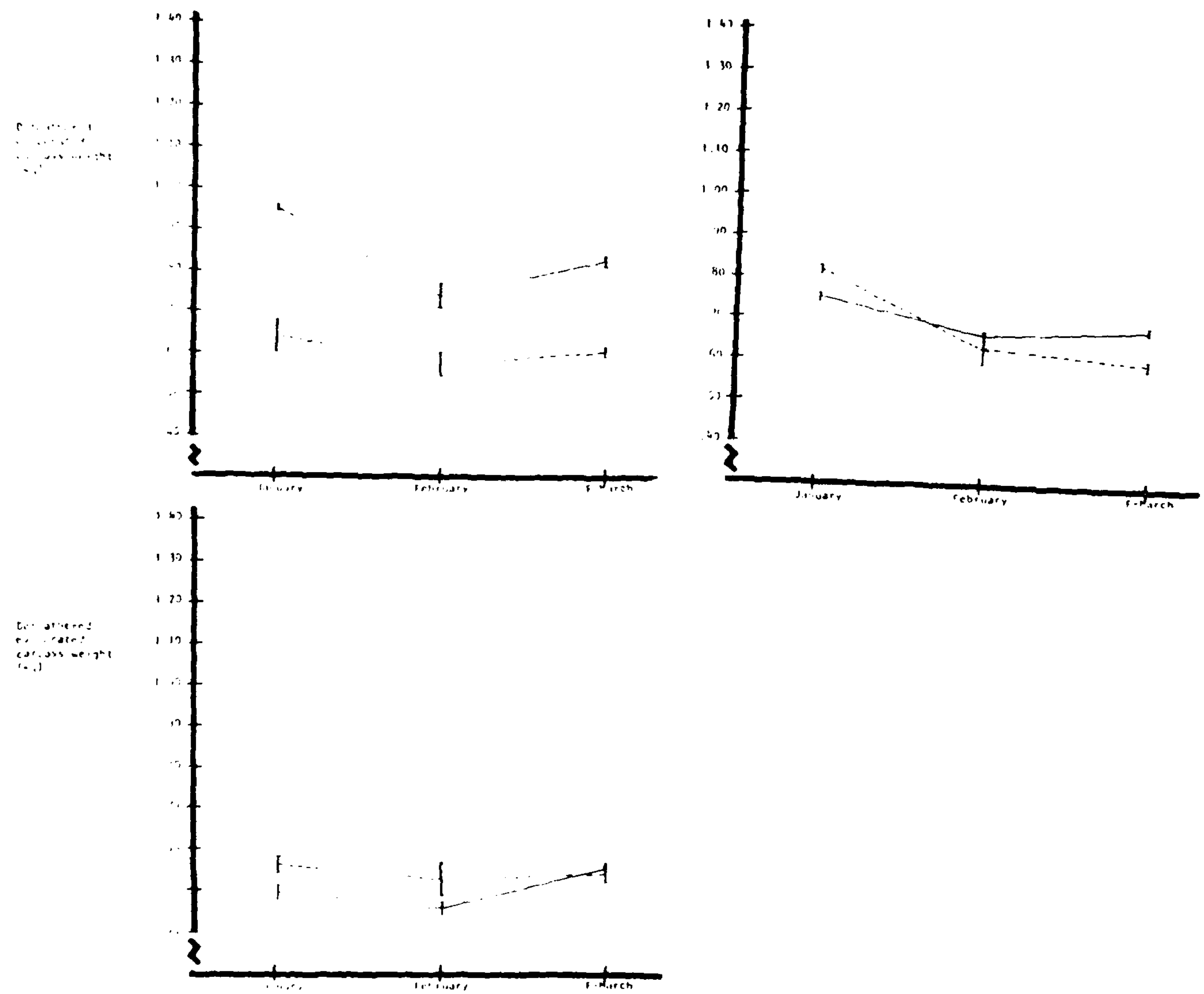


Figure 28. Defeathered evicerated carcass weights of male (solid) and female (dashed) Common goldeneye (left), Greater scaup (right), and Lesser scaup (bottom).

early spring was greatest in January and declined through April, although no birds were collected during February. They hypothesized that observed changes in lipid levels were due to decreased availability of food during winter as a result of ice extending out into Lake Michigan. Ice covered shallow water foraging sites which were presumed to be more productive. Oldsquaws were forced to feed in the less productive deep water sites.

The mean DEC weights for each species and sex were either not significantly different or were significantly higher during Feb-March than during the February period (Fig. 28). Three reasons why DEC weights of waterfowl wintering on the Detroit River did not continue to decline in March include: 1) The mean ambient temperature for the February (1980, 1981) period was -4.6 degrees C. During the Feb-March period, the mean ambient temperature for both years was 1.2 degrees C. This This increase in ambient temperature during the Feb-March period would decrease the energy requirements for ducks and make them less dependent on their endogenous lipid reserves as an energy source. 2) As temperatures during the Feb-March period increased, ice began to breakup, opening up previously unavailable sites for feeding waterfowl. This may result in an increase in food availability. 3) Distribution data indicate a spring migration of diving ducks on the Detroit River began in March for both years of this study. Many of the waterfowl that wintered on the Detroit River had probably moved out of the study area during the last two weeks of collecting. Birds collected at this time were most likely from a different population that had wintered further south, and therefore are likely to have different weights than winter residents from the Detroit River.

From our DEC weight results (Fig. 28), it seems that some ducks are metabolizing stored energy reserves in the form of lipids during February as a result of low food availability and increased energy demands. Ducks that were able to maintain their winter weights throughout the winter were the female goldeneye and lesser scaup, although visual inspection of the carcasses of lesser scaup indicated that the lipid reserves of these birds were low through most of the winter.

Summary (Study Unit 2)

There seems little doubt that the Detroit-St. Clair System, especially the lower Detroit River, is the crucial area on all of the Upper Great Lakes in terms of potential impact of winter shipping on winter waterbird populations. This is due to the relatively high numbers and important species (e.g., canvasback) which use the area, (see AERIAL SURVEY section), as well as the fact that shipping and its accompanying maintenance activities could cause major changes in ice cover, benthos, etc. in this restricted waterway.

The Detroit River has long been noted as an important stopover point during fall migration and as a major wintering site on the Great Lakes for waterfowl. Historical accounts indicate that use of the area by overwintering birds is of relatively recent (since 1930's) origin. This recent use by winter waterfowl is probably attributable to increased amounts of ice-free water present during winter due to thermal and chemical discharge from power plants and factories, in addition to changes in the current velocity in various parts of the river caused by channel modifications.

Although breeding success and hunting mortality undoubtedly influence the number of waterfowl that potentially winter on the Detroit River, our data and observations indicate that early winter weather conditions have an important effect on the number of fall migrants that remain on the river during the winter. The mild temperatures that persisted throughout December 1979 and January 1980 resulted in relatively ice-free conditions on the river that were accompanied by large numbers of wintering waterfowl. Conversely, as a result of unseasonably cold early winter weather in 1980-81, much of the river was ice covered by the first week in January, and the size of the wintering population was substantially lower.

Early January aerial surveys of the river, conducted by the U. S. Fish and Wildlife Service and the Michigan Department of Natural Resources, also indicate that winter waterfowl populations vary widely. However, it is apparent from these data and the present study that substantial numbers of birds use the area and that some of the species which winter here are of special concern (see HISTORIC REVIEW).

During our study, wintering waterfowl were not uniformly dispersed along the river, but exhibited a clumped pattern of distribution. Despite rather large differences in the size of the wintering waterfowl populations and the amount of ice cover during the two years of the study, the concentration sites remained quite similar. This rather consistent pattern of use during both years of the study and under a wide range of weather and ice cover conditions, suggests that these areas contain resources (probably food) that are important to the survival of wintering waterfowl and therefore must be considered as critical habitat.

The concentration sites were typically ice-free, shallow water zones (< 2 m deep) with muck silt substrates that were located ajacent to islands or the mainland. Results from the benthos analysis indicate that shallow water sites were more productive than deep water sites for all important animal foods for the species of ducks collected. Studies of the distribution of wild celery in the Detroit River (Hunt 1963), show that this species is limited to depths

of less than 3.4 m. The depth limitation for pondweeds, and other important plant food, is probably about the same.

Because of the consistently high concentrations of waterfowl at shallow depths for the duration of the winter during both years of the study, and the relatively higher food availability (animal and plant), at shallow vs. deep water sites, it is likely that shallow depths provided most if not all of the foods for wintering waterfowl.

Navigation channels were almost never used by wintering waterfowl. Therefore, the disturbance of waterfowl by ship traffic or ice breaking activities would probably not represent an adverse effect of winter navigation. On the other hand, ice jams resulting from an accumulation of drift ice that was broken during channel clearing activities represent a very real threat to wintering waterfowl. Because the winter navigation demonstration program had ceased prior to our study, we were unable to observe the movement patterns of drift ice that resulted from ice breaking. However, we would expect that naturally occurring drift ice that breaks free during mild weather or spring thaw would behave in a similar manner. During periods of heavy ice movement we frequently observed the formation of ice jams that grew rapidly and could cover a bay or block a channel in a matter of hours.

Even though these naturally occurring ice jams did at times cover important waterfowl feeding and concentration areas, their effect was normally not too severe for two reasons: 1) they generally formed during periods of warm weather when alternate areas of open water were available, and 2) because ambient temperatures were warm, the ice jams usually did not persist for long periods of time.

By contrast, channel clearing activity would be most intense during periods of extreme cold weather when the amount of open water is at a minimum. Drift ice could quickly cover the remaining shallow water areas, freeze, and remain frozen until the temperatures warmed. Under these circumstances, waterfowl could be forced to use the navigation channel where food availability is low (see section on benthos below) or to migrate further south.

If waterfowl did not migrate, but continued to feed in or adjacent to shipping channels, the combined effects of increased energy requirements (for deeper and more frequent dives) and reduced energy intake (due to lowered foraging efficiency) would put ducks into a negative energy balance. Use of carcass endogenous lipid reserves to compensate for the energy deficit would increase energy requirements for thermoregulation because the insulative layer of subcutaneous fat would be depleted. The declines in defeathered eviscerated carcass weights in most of the birds collected in February indicate that these birds were probably depleting their lipid reserves even when the more productive and accessible 2 m sites were available for feeding. It seems unlikely that these birds could survive on the Detroit River if shallow water sites became unavailable for long periods. Because of lipid depletion, the birds could probably not move further south in winter either. Large-scale die-offs have been documented in mid-winter in the area, apparently caused by starvation.

Nearly all of the shallow water concentration areas are vulnerable to being covered by ice jams. Those most susceptible are located in the vicinity of Mud Island (adjacent to Ecorse) and along the Trenton channel (west of Grosse Ile) south to Lake Erie. The waterfowl concentration area located along the west side of Fighting Island would also be subject to being covered by ice because of its close proximity to the channel and the absence of coffer-dams along the navigation channel in this area.

In summary, we believe winter navigation, if initiated, could pose a serious threat to wintering waterfowl for three major reasons. These reasons are: 1) Ice breaking activities could cause ice to be diverted to areas that were previously ice free during winter. Areas that are susceptible to being covered by diverted ice include important foraging sites for wintering water-fowl. This could decrease waterfowl food availability. 2) Winter shipping may adversely affect food abundance by the resuspension of fine substrates. The coarser substrates left behind could limit important waterfowl foods. 3) There is evidence that waterfowl wintering on the Detroit River depleted their endogenous energy reserves even when critical shallow water depths were available for feeding. Any loss of feeding habitat due to long periods of ice cover may force major portions of the population to either migrate when lipid reserves are low, or starve to death.

BREEDING BIRDS AND THEIR WETLAND HABITATS (STUDY UNIT 3)

During 1979 and 1980, potential and/or real impacts of winter shipping activity on select breeding birds and associated habitats were examined at two locations--the Duluth-Superior Harbor and the St. Mary's River. These areas were selected because of their importance to winter shipping, to allow for comparisons between similar wetland types in two different regions, and because of their significance to many bird species.

Restricted waterways such as the connecting channels and harbors of the Great Lakes have been identified as areas most likely to be impacted by winter shipping activity (U. S. Army Corps of Engineers 1979). Both the Duluth Harbor and the St. Mary's River fall into this category, and, in addition, are areas which require significant maintenance activity and modification for winter vessel movement. Increased use of icebreakers, bubbler systems, etc. are necessary, and all of these have potential impact on birdlife. Specific concerns have been outlined previously (U. S. Corps of Engineers 1979).

Wetland habitats were studied for several reasons including: (1) their importance as breeding, feeding, and migratory areas for a large and diverse assemblage of bird species, (2) their overall high biological productivity, (3) their high susceptibility to impacts such as erosion at the land-water interface, and (4) their continued and marked decline in abundance within the Great Lakes systems as well as throughout the United States.

Colonial species and their nesting sites on the St. Mary's River were selected for several reasons. Perhaps most importantly, several colonial-nesting species have undergone significant population declines on the Great Lakes in past years, and some have been classified as threatened or endangered in bordering states. Included in this latter group are the common tern (<u>Sterna hirundo</u>) and great blue heron (<u>Ardea herodius</u>) which nest along the St. Mary's River. Potential losses of nesting habitat and other negative impacts on the breeding success of this and other species are therefore especially important. The sites used by colonial species on the St. Mary's river appear to be particularly susceptible to impact from shipping activity since they are located almost exclusively on small islands and many are near shipping lanes. Erosional effects seem quite possible, and previous work (Scharf 1978, Scharf et al. 1979) indicates that some of these sites may have been affected in this way in prior years.

<u>Wetlands studies</u>

The primary objective of the wetlands studies was to determine whether or not past winter shipping activities (during the demonstration program) have influenced the character of either the marsh vegetation or the associated bird community. To this end, the investigation used a comparative approach in which both marshes remote from and adjacent to winter shipping lanes were studied. The data collected may also be valuable in making subsequent comparisons with the results of future sampling (e.g., time series analyses). Because shipping has occurred for a number of years in some areas, no "before-after" experimental design was possible (Ward 1978).

The experimental design was such that an equal number of wetland study sites were located adjacent to and remote from winter shipping lanes. Remote or unexposed sites were treated as controls and adjacent or exposed sites as potential "treatment" areas. An attempt was made to subjectively match gross marsh types in these two groups (this was later tested via vegetation analyses). Most work concentrated on persistent emergent wetland types since these were predominant in both study areas. According to the most recent U. S. Fish and Wildlife Service classification scheme (Cowardin et al. 1979), the interior portions of the sites were persistent emergent aquatic palustrine while the shorelines tended toward non-persistent emergent aquatic lacustrine or riverine systems.

Study plots were located within each marsh, and these comprised the working unit for all bird and vegetation studies and were placed in areas of relatively homogeneous vegetation which appeared representative of the given wetland. Plots were located such that each was surrounded by a minimum buffer zone 10 m from the shoreline and 25 m from distinctly different habitat types. With minor exceptions, plot size was 1.0 (100 m x 100 m) and 0.5 (50 m x 100 m) ha in the Duluth and St. Mary's study sites respectively (Tables 32 and 33). Each was marked using corner poles, and plastic flagging, placed at 25 m intervals, was used to mark exterior boundaries as well as interior grids.

Twelve 1 ha plots, six in the main harbor and six remote from harbor activity, were selected for study in Duluth (Figure 29 and Table 32). Of the six plots considered in potential impact areas, only two, the Hog Island and Nemadji river sites, are actually close to shipping lanes. The remaining four, all located in Allouez Bay, are somewhat distant from activity (2-4 km).

Similarly, twelve 0.5 ha plots were selected for study in the St. Mary's River area (Figure 30 and Table 33). During the second year of the study, two of these original plots and four new ones were included because of a change in logistical support.

Wetlands Breeding Birds

Methods

Passerine breeding populations on the study plots were censused during May and June of 1979 and 1980 using territorial spot-mapping techniques (Williams 1937). All 24 original plots, 12 in Duluth and 12 in the St. Mary's River, were censused in 1979, but only 8 of 12 in Duluth and 2 of 12 in the St. Mary's area were repeated in 1980. The four new wetland sites added to the St. Mary's Study in 1980 were also censused that year.

Data for spot-maps were collected in general accordance with international guidelines (Robbins 1970). Observations were made between 0500 and 1000 local daylight time, and the plot sequence was rotated each day to avoid time-of day bias. A complete census, i.e., one census of each plot, usually required two days in either study area. In the larger Duluth plots, two routes, one

Table 32. Wetland Study Plots in the St. Louis River Estuary.

Plot name	Shipping status[a]	Dimensions (m)	Years studied			
			Breeding birds		Vegetation	
			1979	1980	1979	1980
Allouez Bay #1	E	100 x 100	x	x	x	x
Allouez Bay #2	E	100 x 100	x	x	x	x
Allouez Bay #3	E	100 x 100	x		x	x
Allouez Bay #4	E	100 x 100	x		x	x
Nemadji River	E	100 x 100	x	x	x	x
Hog Island	E	110 x 90	x	x	x	x
Oliver Bridge	U	100 x 100	x	x	x	x
Spirit Lake #1	U	100 x 100	x	x	x	x
Spirit Lake #2	U	100 x 100	x	x	x	x
Spirit Lake #3	U	100 x 100	x	x	x	x
Mud Lake	U	100 x 100	x		x	x
Spirit Lake Point	U	110 x 90	x		x	x

[a] E signifies exposed or adjacent to shipping, U signifies unexposed or remote from shipping.

Table 33. Wetland Study Plots on the St. Mary's River.

Plot name	Shipping status	Size (ha)	Years studied[a] Breeding birds 1979	Breeding birds 1980	Vegetation 1979	Vegetation 1980
Mike's Landing Culvert	E	0.5	x		x	
Mike's Landing II	E	0.5	x		x	
Flory's Fortress	E	0.5	x		x	
12-mile Road I	E	0.5	x	x	x	x
12-mile Road II	E	0.5	x		x	
12-mile Road III	E	0.5	x		x	
9-mile Road I	E	0.5		x		
9-mile Road II	E	0.5				x
Whitehouse I	U	0.5	x	x	x	x
Whitehouse II	U	0.5	x		x	
Whitehouse III	U	0.5	x		x	
Munuscong Dike I	U	0.5	x		x	
Munuscong Dike II	U	0.5	x		x	
Munuscong Dike III	U	0.5	x		x	
Kemp's Point Cove	U	0.5		x		x
Redhouse	U	0.5		x		x

[a]Because of reduced logistical support, work was intensified at fewer sites in 1980 compared to 1979.

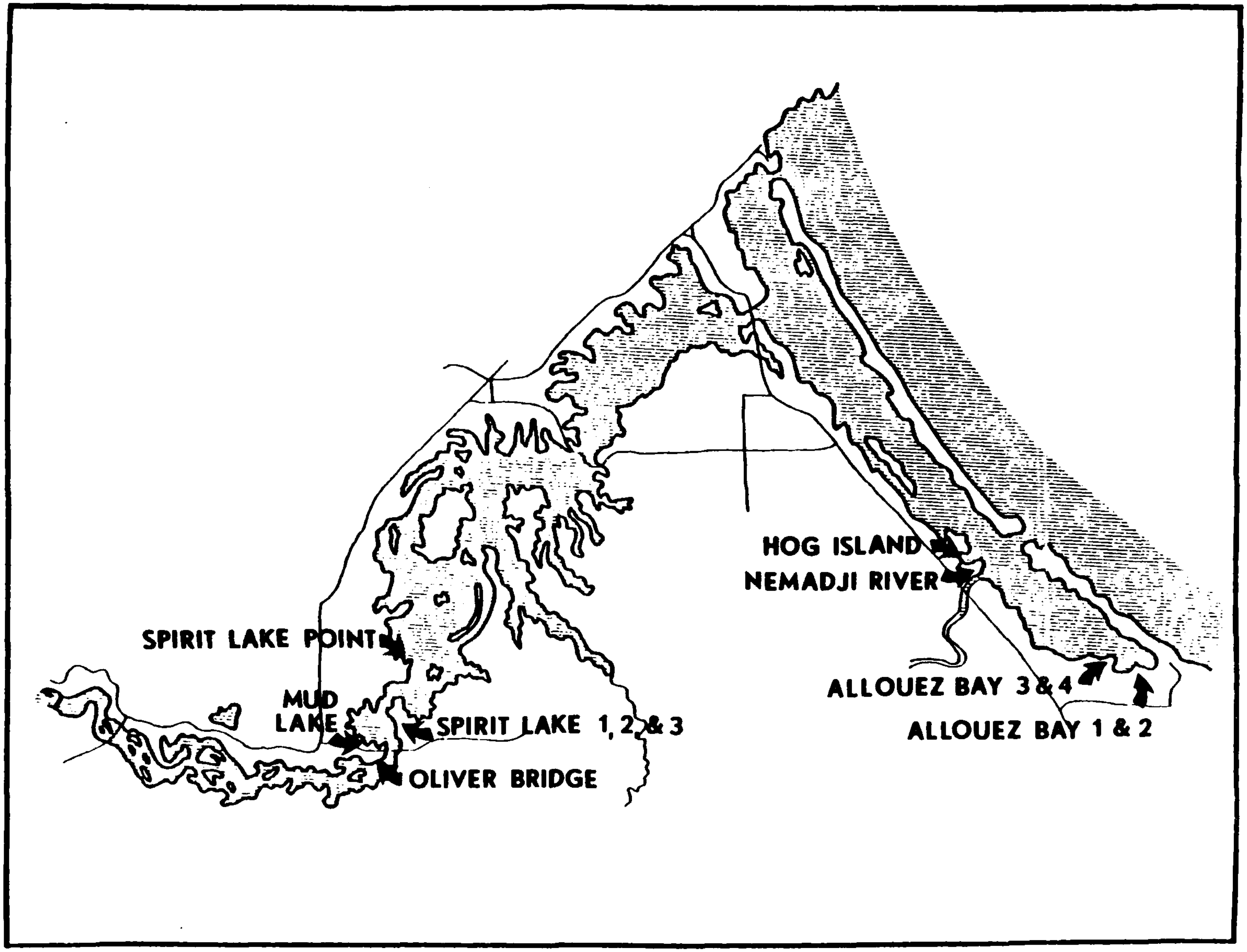


Figure 29. Locations of wetland study sites used in 1979 and 1980 in the Duluth-Superior Harbor-St. Louis estuary region.

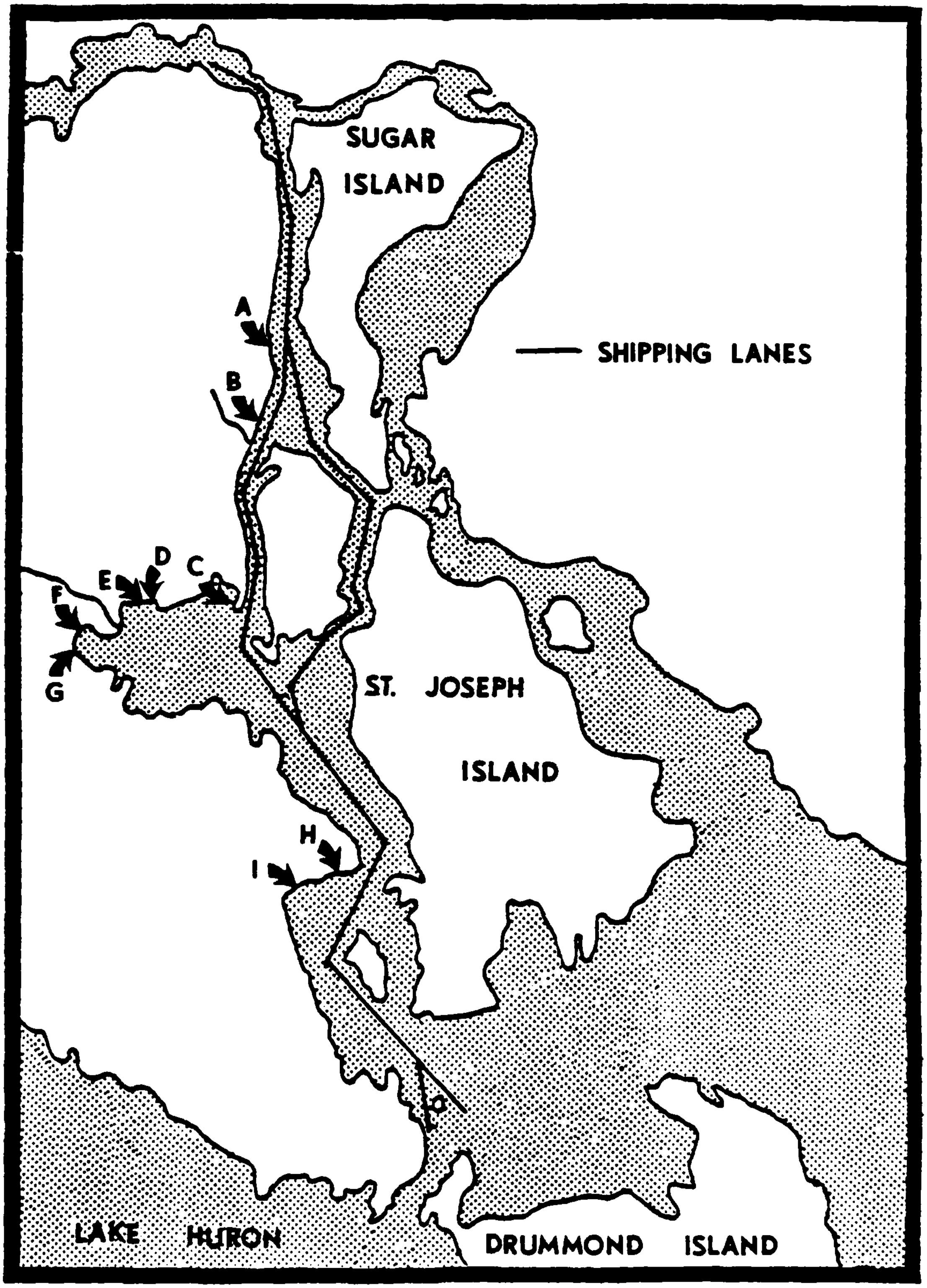


Figure 30. St. Mary's River wetland study plots: A=9-mile road; B=12-mile road, C=Kemp's Point Cove; D=Red House; E=White House; F=Munoscong Dike (1-2); G=Munoscong #3; H=Flory's Fortress; I=Mike's Landing.

around the perimeter of the plot and one traversing the interior grid system, were used on alternate censuses. The time spent on each plot was standardized. The total number of censuses per plot ranged from 6-9 per year.

Two sets of composite maps of bird use of each plot were constructed. The first included maps showing all observations of territorial males by species and census day. These were used to determine territory boundaries and ultimately breeding densities. The second set of maps displayed all bird sightings and thus included non-breeding birds and nesting females as well as territorial males. From these maps, tables were formulated to summarize the frequency of observation and mean number of individuals seen per census for each species.

In addition to the above censuses, nest counts were made on each plot. In 1979, no special effort was made to locate nests, and those recorded were found during normal census procedures. However, in 1980, two separate nest searches, one early and one midway through the nesting season, were made on each plot. These searches consisted of walking within each plot not normally traversed during census procedures. Likely nest sites, as indicated by previous observations of bird behavior, were searched intensively.

No special attempts were made to census nonpasserine birds because of time limitations. Some data were collected incidentally on waterfowl and rails.

Several statistical analyses of the census data were made. Most were aimed at detecting significant differences in breeding bird populations on the plots as a function of year and treatment group (i.e., adjacent or remote from shipping). As such, one-way and two-way ANOVAs were run using total (all species) breeding population densities, breeding populations of the dominant species, and species richness as the test parameters. In addition, census figures were compared to nest counts for 1980 on a plot by plot basis using a Wilcoxon matched pairs test.

Results--Duluth-Superior

Results of the breeding bird censuses in Duluth are presented in Table 34. With few exceptions, the dominant species was the red-winged blackbird. This species was present on all study plots, and its apparent breeding density ranged from 20 to as high as 60 territories per 10 ha. The only other breeding bird which was present in most study plots was the long-billed marsh wren. It was usually present at a far lower density than the red-winged blackbird, although it was equally abundant at two remote sites, Mud Lake and Spirit Lake Point.

With one exception, no significant differences in breeding populations as a function of year or location with respect to shipping lanes were found. This applies to individual species as well as overall passerine populations and to single study plots as well as the study area as a whole.

Total breeding densities, including all species registered using territorial spot-mapping, showed no change from year to year ($F=0.39$, $p=0.54$,

Table 34. Breeding Bird Summary for Wetland Plots, Duluth.

Plot and species	Territories per 10 ha 1979	Territories per 10 ha 1980	Nests per 10 ha 1979	Nests per 10 ha 1980	Total individuals per census 1979	Total individuals per census 1980
Hog Island						
Red-winged blackbird (_Agelaius phoeniceus_)	58	49	20	50	12.6	14.3
Mallard (_Anas platyrhynchos_)	10	10	10	10	1.6	1.2
Namadji River						
Red-winged blackbird	33	46	40	30	6.3	8.7
Long-billed marsh wren (_Telmatodytes palustris_)	0	0	0	0	0.0	1.0
Allouez Bay #1						
Red-winged blackbird	58	68	40	50	10.0	14.5
Long-billed marsh wren	10	0	0	0	1.3	0.0
Yellowthroat (_Geothlypis trichas_)	8	0	0	0	0.9	0.0
Sora (_Porzana carolina_)	0	6	0	0	0.6	0.5
Swamp sparrow (_Melospiza georgiana_)	4	0	0	0	0.4	0.0
Allouez Bay #2						
Red-winged blackbird	51	55	40	50	11.6	9.2
Sora	23	15	10	10	1.5	1.0
American Coot (_Fulica americana_)	10	0	10	0	0.0	0.0
Common Snipe (_Capella gallinago_)	0	10	0	10	0.0	0.0
Allouez Bay #3						
Red-winged blackbird	54	--	30	--	11.5	--
Sora	14	--	0	--	0.9	--
Long-billed marsh wren	7	--	0	--	0.6	--
Allouez Bay #4						
Red-winged blackbird	60	--	50	--	9.5	--
Swamp sparrow	17	--	0	--	1.3	--
Virginia rail (_Rallus limicola_)	16	--	0	--	0.0	--
Mallard	10	--	0	--	1.0	--
Yellowthroat	10	--	0	--	0.5	--

Table 34 (continued)

Plot and species	Territories per 10 ha		Nests per 10 ha		Total individuals per census	
	1979	1980	1979	1980	1979	1980
Oliver Bridge						
Red-winged blackbird	35	35	10	10	6.6	8.0
Swamp sparrow	16	0	0	0	1.1	0.0
Long-billed marsh wren	0	24	0	10	0.0	1.5
Spirit Lake #1						
Red-winged blackbird	60	56	0	40	7.1	7.8
Long-billed marsh wren	8	28	10	20	1.0	2.3
Sora	10	+[a]	10	0	1.0	0.0
Blue-winged teal (*Anas discors*)	10	0	0	0	1.4	0.0
Yellow-headed blackbird (*Xanthocephalus xanthocephalus*)	5	0	0	0	0.4	0.0
Spirit Lake #2						
Red-winged blackbird	47	48	0	20	8.0	12.2
Long-billed marsh wren	8	19	0	0	0.4	2.2
Sora	10	0	0	0	0.6	0.0
Yellowthroat	10	0	0	0	0.4	0.0
Spirit Lake #3						
Red-winged blackbird	43	57	30	40	21.0	12.3
Long-billed marsh wren	4	13	0	10	0.5	1.0
Virginia rail	10	+[a]	0	0	0.4	0.3
Mud Lake						
Red-winged blackbird	20	--	20	--	5.5	--
Long-billed marsh wren	28	--	10	--	2.6	--
Swamp sparrow	27	--	0	--	1.9	--

Table 34 (concluded).

Plot and species	Territories per 10 ha		Nests per 10 ha		Total individuals per census	
	1979	1980	1979	1980	1979	1980
Spirit Lake Point						
Long-billed marsh wren	48	--	0	--	3.9	--
Red-winged blackbird	40	--	2	--	6.1	--
Virginia rail	10	--	0	--	0.5	--
Yellowthroat	7	--	0	--	0.4	--
Swamp sparrow	3	--	0	--	0.4	--

[a]+indicates present, but at less than 0.5 per 10 ha.

df=12) and varied from 68 to 78 territories per 10 ha. Similarly, no differences between treatments were evident ($F=0.20$, $p=0.63$, $df=1$). The two-year means for adjacent and remote marshes (using only the four marshes censused both years) were 66 and 70 territories per 10 ha, respectively.

Species richness was low throughout the estuary, and, although minor changes did occur on a plot by plot basis, overall richness was unchanged from 1979 to 1980 ($F=2.5$, $p=0.14$, $df=12$). No difference in richness between treatment groups was found either ($F=1.3$, $p=0.28$, $df=12$). The mean number of species present per plot for the two-year period was 2.7 and varied from as low as 1.0 to as high as 5.0. In those instances in which a single species was present, it was always the red-winged blackbird.

No significant differences in the breeding density of the dominant red-winged blackbird as a function of treatment group ($F=0.68$, $p=0.43$, $df=12$) or year ($F=0.5$, $p=0.49$, $df=12$) were found. The mean population throughout the study area was 42 and 55 territories per 10 ha during 1979 and 1980 respectively. The density on a given plot did not show much change either (Table 34).

In contrast to the above species, the long-billed marsh wren did show some significant differences in breeding density with respect to both year and location. The data indicate that populations were significantly higher in the remote marshes ($F=28.0$, $p=0.0002$, $df=12$), and that the overall population increased from 1979 to 1980 ($F=8.9$, $p=0.01$, $df=1$). This species was essentially absent from the exposed marshes during both years of the study, and had a mean breeding density of 0.0 and 2.5 territories per 10 ha in 1979 and 1980, respectively, on these plots. There was a significant interactive component between year and treatment ($F=16.8$, $p=0.001$, $df=1$).

The number of nests found on the study plots was quite variable and did not appear to have a simple relationship with territory estimates (spot-map results). Using 1980 data for the abundant red-winged blackbird to test for a relationship between those two estimators of breeding density, it appeared they were significantly different. Both a paired t-test ($F=4.59$, $p=0.0001$, $df=7$) and a Wilcoxon matched pairs test ($p=0.03$) showed them to be different.

Results--St. Mary's River

Results of the breeding bird censuses in the St. Mary's River area are presented in Table 35. As in Duluth, the dominant species was the red-winged blackbird. This species was present on all plots and was the only passerine recorded as a breeding bird on several of them. Red-wing territory density ranged from 5.6 to 196.0 per 10 ha, and, in most cases, was far greater than other species present on a given plot. The only other species occurring on a large number of plots was the swamp sparrow. Its breeding density generally was far less than that of the red-winged blackbird, and its occurrence appears to reflect the presence of shrubs in or near plots. The territory density of this species did exceed 20.0 per 10 ha in several plots however, and it actually was the dominant species at the Redhouse plot (66.0 per 10 ha).

Table 35. Breeding Bird Summary for Wetland Plots, St. Mary's River.

Plot and species	Territories per 10 ha		Nests per 10 ha		Total individuals per census	
	1979	1980	1979	1980	1979	1980
Mike's Landing Culvert[a]						
Red-winged blackbird	80	--	60	--	88	--
Swamp sparrow	10	--	0	--	4	--
Mike's Landing #2[a]						
Red-winged blackbird	94	--	40	--	63	--
Flory's Fortress[a]						
Red-winged blackbird	94	--	0	--	63	--
12-mile Road #1[a]						
Red-winged blackbird	80	40	20	60	42	45
Yellow warbler	12	0	0	0	8	0
12-mile Road #2[a]						
Red-winged blackbird	56	--	40	--	31	--
12-mile Road #3[a]						
Red-winged blackbird	48	--	0	--	39	--
9-mile Road #1[a]						
Red-winged blackbird	--	52	--	40	51	--
Swamp sparrow	--	20	--	0	20	--
Whitehouse #1[a]						
Red-winged blackbird	72	196	20	20	31	31
Swamp sparrow	18	40	0	0	8	18
Long-billed marsh wren	0	16	0	0	0	13
Whitehouse #2						
Red-winged blackbird	60	--	0	--	63	--

Table 35 (concluded).

Plot and species	Territories per 10 ha 1979	Territories per 10 ha 1980	Nests per 10 ha 1979	Nests per 10 ha 1980	Total individuals per census 1979	Total individuals per census 1980
Whitehouse #3						
Red-winged blackbird	88	--	20	--	66	--
Munuscong Dike #1						
Red-winged blackbird	58	--	20	--	33	--
Swamp sparrow	40	--	0	--	7	--
Yellow warbler (*Dendroica petechia*)	20	--	0	--	5	--
Munuscong Dike #2						
Red-winged blackbird	60	--	20	--	37	--
Swamp sparrow	20	--	0	--	8	--
Munuscong Dike #3						
Yellow warbler	56	--	0	--	24	--
Swamp sparrow	32	--	0	--	13	--
Red-winged blackbird	14	--	0	--	22	--
Kemp's Point Cove						
Red-winged blackbird	--	90	--	20	--	98
Long-billed marsh wren	--	20	--	40	--	1
Red House						
Swamp sparrow	--	66	--	0	--	51
Savannah sparrow (*Passerculus sandwichensis*)	--	14	--	0	--	8
Red-winged blackbird	--	6	--	0	--	10

[a]Denotes marshes more exposed to shipping; the rest are remote.

No significant differences in breeding bird populations as a function of year or location with respect to shipping were found. Total breeding populations, including all species observed, were quite variable both within and between treatment groups, and, although the mean difference between adjacent and remote marshes is large, it is not statistically significant ($F=1.9$, $p=0.19$, $df=10$). The difference observed primarily reflects the fact that red-winged blackbird densities were somewhat higher in the remote marshes. Once again, this apparent difference is not statistically significant ($F=0.6$, $p=0.46$, $df=10$).

As in Duluth, species richness was low throughout the river. Mean values for remote and adjacent marshes were 2.0 and 1.3 respectively. This difference is not significant ($F=2.5$, $p=0.14$, $df=14$). Since only two marshes were censused both years, year to year changes were not examined.

Wetland Vegetation

Methods

The vegetation present on each study plot was quantified through an intensive sampling scheme using 1 m^2 quadrats located along designated transects (Figure 31). All data were collected as percent cover estimated to the nearest 5% by species or genus on each quadrat. In some instances, additional 20 x 50 cm quadrats were located within the 1 m^2 quadrats, and these were used to estimate percent cover for dense species. Vegetation sampling in the St. Mary's River study area was conducted during early July of both years. In Duluth, sampling was synchronized with the apparent maximum in vegetation cover each year (late July to early August). Species identifications were made using Gray's Manual of Botany (Fernald 1950), Common Marsh, Underwater, and Floating-leaved Plants of the United States and Canada (Hotchkiss 1967), and Fasset's Manual of Aquatic Plants (Fasset 1975).

Three basic transect-quadrat layouts were used. The first incorporated quadrats located at regular intervals (every 5 m in Duluth and every 10 m in the St. Mary's River) along a transect which began at the shoreline and ran inland on a perpendicular to it. These samples therefore included data representing the shoreline, near-shore, and interior portions of the given wetland and gave an overall picture of the vegetation present. In Duluth, these transects were 100 m long, but due to the small sizes of some marshes in the St. Mary's River, two 50 m transects were used in some cases. In Duluth, two such transects were sampled at each site during 1979, and one of each pair was sampled again in 1980. In the St. Mary's River area, only one such transect was sampled in 1979; these were sampled again at the two sites which remained in the study during 1980. The origination point of each transect was chosen at random with the exception of those plots in which two transects were used. In these cases, the first was chosen at random, but the second was selected randomly only from those points more than 25 m from the first.

The second transect-quadrat system also used transects which began at the shoreline and ran inland on a perpendicular to it. However, these transects were only 45 m in length and thus included only the near-shore vegetation.

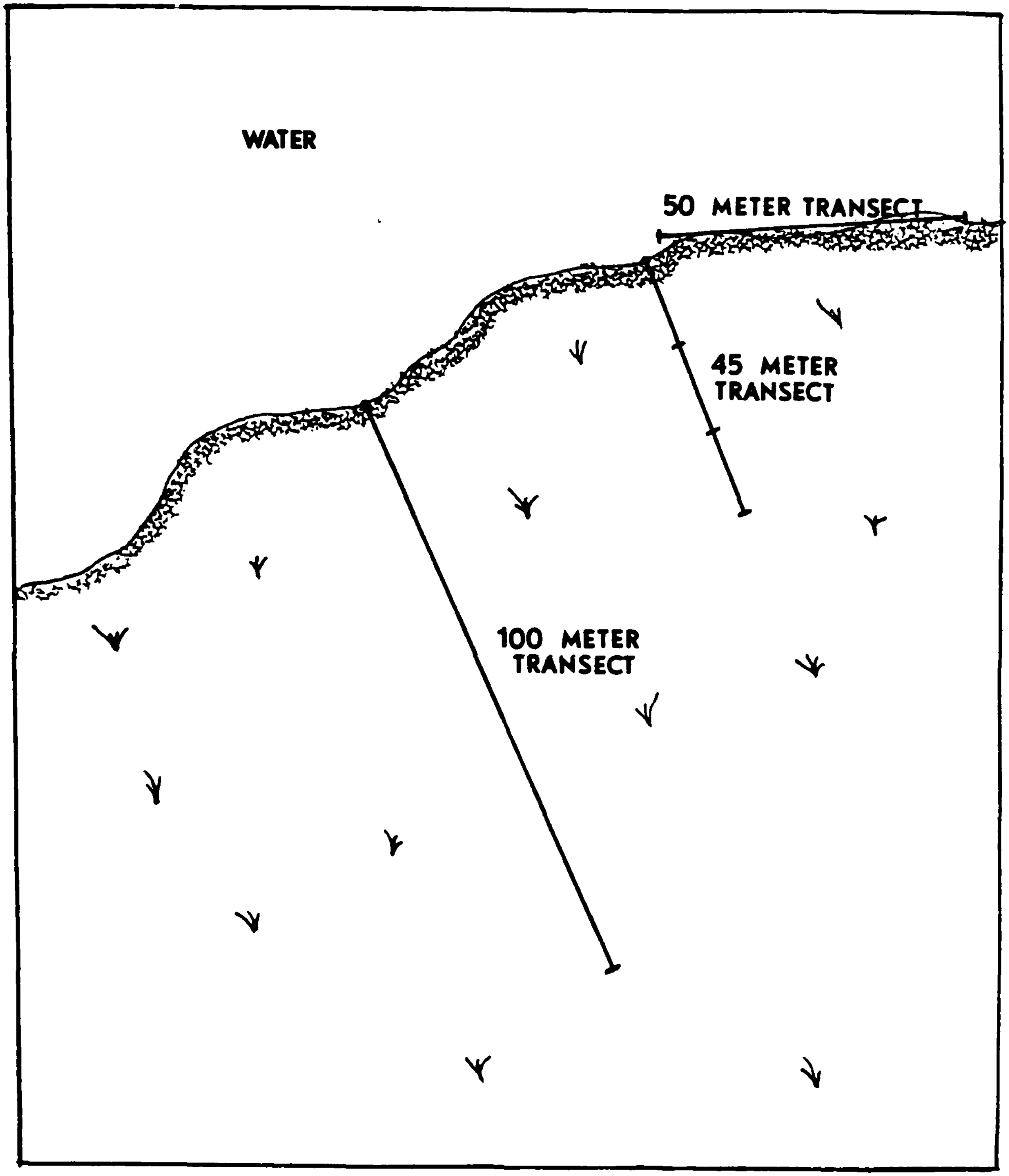


Figure 31. Vegetation transect scheme used in Duluth-St. Louis River and St. Mary's River study sites.

Each of these transects was located randomly and was further divided into three equal 15 m segments (Figure 31). Within each segment, five 1 m^2 quadrats, located randomly but without repetition, were sampled. One such transect was sampled in each marsh studied during 1980.

The final sampling scheme used 50 m transects located randomly along the shoreline of each marsh and parallel to it. These lay outside the actual study plots, but directly adjacent to them. Shoreline was defined as the area within 2 m of open water. Five 1 m^2 plots, selected randomly but without repetition, were sampled along each transect. One such transect was sampled in each marsh studied during 1980.

In addition to the above sampling schemes, the vegetation in each study plot was further documented using both ground and aerial photography. In the St. Mary's area, oblique shots using a hand-held 35 mm camera and color slide film were taken of each site. In Duluth, both oblique and standard vertical photographs were taken. The vertical photographs were shot from about 675 m and 1350 m using a belly mount system and B & W plus X aerographic film. These photographs are included in Appendix F.

Several statistical tests and/or summaries of the data derived from the various sampling schemes were made. The first includes a summary of the % cover data by species for each study plot by year and transect type. The mean % cover and its standard deviation, relative % cover, relative frequency, and composite importance value for each transect type were calculated. The latter value is calculated as:

$$\text{I. V.} = \frac{\text{relative \% cover} + \text{relative frequency}}{2}$$

Abbreviated summaries of only the dominant species are given in Appendix G.

Yearly Variation

In order to determine if there was appreciable year to year variation in the measured vegetation, a Wilcoxon matched-pairs test was run on the dominant species present on each study plot. The matched pairs were the two years of % cover data for each quadrat. Since only single whole-marsh (100 m) transects were actually sampled both years, only data from those transects were used. Each marsh and species was tested separately.

Comparison of Adjacent and Remote Plots

Several tests were made to assess whether or not significant differences in vegetation characteristics existed between those marshes remote from and adjacent to shipping lanes. All used % cover per quadrat as the basic data set.

The first series of tests used data from the shoreline transects. The sampling scheme for these has already been described. Percent cover data for each plot was used to compare plot similarity within each marsh, and then marshes were compared using the mean percent cover based on 5 quadrats for each species. A modified Bray-Curtis Similarity Index (see Huhta 1979) was used to make pairwise comparisons of all marshes:

$$\text{BC index} = 1 - \frac{| n^*_{1i} - n^*_{2i} |}{(n^*_{1i} - n_{2i})}$$

where $n^*_{1i} = \ln (n_{1i} + 1)$ and $n^*_{2i} = \ln (n_{2i} + 1)$ and the n_i are the proportional cover values (p_i) for each species in samples 1 and 2. A computer program was used to generate a matrix of similarity values for all pairwise comparisons. Mean species richness for each marsh and treatment group was calculated also.

The second series of tests utilized data from the near-shore (45 m) transects which were sampled in 1980. The sampling scheme has already been described. A two-way ANOVA was run in which the effects of distance from shoreline and location with respect to shipping lanes on percent cover of the dominant species were assessed. The three 15 m segments of each transect were used as distance groups, those segments near, medium distance from, and far from shore. The mean percent cover of the dominant species was calculated for each 15 m segment for each treatment group as well as for individual plots in each study area. The two-way ANOVA allowed interactive effects between distance and treatment group to be assessed.

In a similar manner, mean species richness was calculated for each 15 m segment in each marsh and for each treatment group as a whole. Once again, a two-way ANOVA was run in which the effects of distance from shore and location with respect to shipping were examined.

The final series of tests assessed the between-treatment differences in vegetation using the whole-marsh (100 m) transect data from 1979. Mean percent cover by species was calculated for each marsh, and these values were used to calculate a Kendall's Tau Similarity Index (Ghent 1963) for all marsh pairs within each study area. Only species present in at least one of the two marshes being compared were included in the calculations, and species absent in a marsh but included in the calculations were assigned last place rank. The indices were corrected for ties (Ghent 1963).

Results - Duluth

A summary of the dominant vegetation present within each study plot is given in Appendix G.

Near-shore (45 m) Transects

Of the eleven plant taxa tested, four showed significant overall differences ($p \leq 0.05$) in percent cover as a function of distance from shore, and six showed significant differences in abundance between treatment groups (Table 36). Of those demonstrating a relationship with distance, *Sparganium eurycarpum* and *Sagittaria latifolia* decreased with distance, while *Calla palustris* increased. Although *Scirpus* appeared to occur almost exclusively in the block 15 to 30 m from shore, this represents only one marsh and thus one transect in Allouez Bay #3, the only plot in which *Scirpus* was found.

Tests of the treatment effect of location relative to shipping on each species produced mixed results. Four were more abundant in exposed marshes

Table 36. Summary of Two-way ANOVA Tests for Differences in Plant Species Abundance in Near-shore (45 m) Transects, Duluth.

Species	Abundance with distance from shore[a]	Abundance with shipping states[b]	Interaction effect[c]
Typha spp.	n.s	n.s	p=0.02
Sparganium eurycarpum	p=0.01 (-)	n.s	n.s.
Equisetum spp.	n.s	p=0.04 (+)	n.s
Sagittaria latifolia	p=0.001 (-)		n.s
Carex spp.	n.s		p=0.003
Scirpus spp.	p=0.01 (mixed)	p=0.02 (+)	n.s
Calla palustris	p=0.001 (+)	p=0.001 (-)	p=0.002
Phragmites communis	n.s	p=0.002 (+)	n.s
Spirodella polyrhiza	n.s	p=0.002 (-)	p=0.03
Acorus calamus	n.s	p=0.01 (+)	n.s

[a] (+) indicates increase in abundance with increasing distance from water's edge. (-) indicates decrease in abundance with increasing distance from water's edge.
[b] (+) indicates more abundant in marshes adjacent to shipping lanes. (-) indicates less abundant in marshes remote from shipping lanes.
[c] Interaction between abundance/distance profile and shipping status.

and two were more abundant in remote marshes. Again, Scirpus was more abundant in the exposed plots only because of its presence in Allouez Bay #3.

In addition, four taxa showed significant interaction between their abundance-distance profile and treatment group. As in the above, the type of difference was mixed with some showing increased abundance with distance in one group and decreased in the other, some showing the converse of this (Table 36).

There was considerable variation in overall and single quadrat species richness among marshes exposed to shipping lanes, but not in those in the remote group. And, while overall richness in the two treatment groups appeared quite similar, 4.77 in adjacent and 5.31 in remote, the difference is significant (df=1, p=0.04). Thus the remote marshes had slightly higher diversity in the 45 m zone next to the shoreline than those marshes adjacent to shipping channels.

No significant differences in species richness with respect to distance from shore were found, but the interactive effect of treatment group and richness-distance profile is significant (df=2, p=0.03). Mean species richness in adjacent marshes appeared to be the same for all three 15 m zones, but showed a decided decline with distance in the remote plots.

Shoreline Transects

Mean similarities were quite high within marsh, especially in the remote treatment group (Table 37). A t-test comparing mean similarities between remote and adjacent marshes showed no difference (t=0.70, df=10, p=0.50) between the two. Similarly, using the mean values from the five plots within each marsh to make whole-marsh comparisons, no differences in similarity among the remote group ($X_{BC}=0.35 \pm 0.23$), among the adjacent marshes ($X_{BC}=0.31 \pm 0.23$), or between the two types ($\overline{X}_{BC}=0.32 \pm 0.25$) were found.

Overall species richness in the shoreline vegetation had considerable variation (Table 38). There did not appear to be any significant treatment effect, although adjacent marshes, on average, had slightly more species than remote marshes. In all cases, richness was quite low and a few species (e.g., Typha, Sparganium, etc.) dominated.

Whole-marsh Transects (Kendall's Tau Comparisons)

A total of sixteen pair-wise comparisons of marshes using Kendall's Tau showed significantly similar vegetation characteristics (at $p \leq 0.05$, Table 39). Of the remote marshes, all but two, Mud Lake and Spirit Lake Point, could be "matched" with one or more marshes in the adjacent group, and all but Allouez Bay #1 from within the adjacent group could likewise be "matched" with one or more marshes from the remote group.

There appears to be far more variability within the adjacent marshes group as only one pair, Allouez Bay #2 and #4, were significantly similar ($\Gamma=0.28$, p=0.02). In contrast, six similar pairs were found within the remote group. Probability alone would predict that, in making 15 comparisons in each

Table 37. Within-marsh Shoreline Vegetation Similarity Index Values[a] for 12 Duluth Harbor-St. Louis River Estuary Marsh Sites, 1980.

Marsh	Mean	S. D.	Range
Remote			
Bridge	0.87	0.10	0.71-1.00
So. Spirit Lake 1	0.85	0.10	0.69-0.96
So. Spirit Lake 2	0.66	0.17	0.41-0.94
So. Spirit Lake 3	0.96	0.02	0.92-0.99
Mud Lake	0.80	0.14	0.64-0.98
Spirit Lake Pt.	0.92	0.03	0.87-0.97
Median = 0.86			
Adjacent			
Hog Island	0.97	0.02	0.93-1.00
Nemadji River	0.98	0.02	0.95-1.00
Allouez 1	0.58	0.17	0.26-0.88
Allouez 2	0.76	0.10	0.59-0.91
Allouez 3	0.74	0.17	0.50-0.97
Allouez 4	0.71	0.12	0.55-0.96
Median = 0.75			

[a]Bray-Curtis similarity index values, based on 10 pairwise comparisons of the 5 plots in each marsh.

Table 38. Species Richness of Herbaceous Vegetation on Shoreline of Wetland Plots, Duluth Harbor.

Marsh		No. species[a]
Remote from shipping		
Oliver Bridge		1.2 ± 0.4
Spirit Lake #1		2.4 ± 1.1
Spirit Lake #2		2.0 ± 0.0
Spirit Lake #3		2.2 ± 0.4
Mud Lake		1.6 ± 0.5
Spirit Lake Point		3.0 ± 0.0
	Overall mean	2.1 ± 0.6
Adjacent to shipping		
Hog Island		1.0 ± 0.0
Nemadji River		2.2 ± 0.4
Allouez Bay #1		1.0 ± 0.0
Allouez Bay #2		4.6 ± 1.3
Allouez Bay #3		2.8 ± 0.8
Allouez Bay #4		3.2 ± 0.4
	Overall mean	2.5 ± 1.4

[a]Mean ± 1 standard deviation, based on five 1-m^2 plots in each marsh.

Table 39. Summary of Kendall's Tau[a] Comparisons of Vegetation in Wetland Plots, Duluth Harbor.

Marsh	Marsh: Adjacent to shipping						Marsh: Remote from shipping					
	Hog Island	Nemadji River	Allouez Bay #1	Allouez Bay #2	Allouez Bay #3	Allouez Bay #4	Oliver Bridge	Mud Lake	Spirit Lake #1	Spirit Lake #2	Spirit Lake #2	Spirit Lake Point
Adjacent												
Hog Island	--											
Nemadji River	0.06	--										
Allouez Bay #1	0.13	-0.04										
Allouez Bay #2	-0.15	0.00	0.25	--								
Allouez Bay #3	0.19	0.22	0.11	0.19	--							
Allouez Bay #4	0.21	0.17	0.19	0.28[b]	0.21	--						
Remote												
Oliver Bridge	-0.02	0.27[b]	0.09	0.18	0.19	0.10	--					
Mud Lake	0.06	0.17	0.11	0.05	0.17	0.21	0.15	--				
Spirit Lake #1	0.29[b]	0.28[b]	0.07	0.11	0.42[b]	0.15	0.19	0.25	--			
Spirit Lake #2	0.14	0.22	0.17	0.28[b]	0.47[b]	0.34[b]	0.41[b]	0.19	0.22	--		
Spirit Lake #3	0.16	0.25	-0.05	0.06	0.40[b]	0.24[b]	0.26[b]	0.27[b]	0.49[b]	0.36[b]	--	
Spirit Lake Point	0.02	-0.12	0.09	-0.03	0.14	0.18	-0.09[b]	0.29[b]	0.05	-0.03	0.10	--

[a]Based on mean % cover of all species present in at least one of two marshes being compared, zero values were assigned last place rank and Tau was correct for ties; data taken from interior (100m) transects, 1979.
[b]Signifies significant similarity at $p = 0.05$ level.

treatment group, close to one comparison (0.75) should prove significant using a 95% level criterion. Thus, "remote" marshes are more similar to each other than the null hypothesis would predict.

Few species showed any significant difference in abundance between 1979 and 1980 (Table 40). Thus it appears that no real change in overall vegetation occurred in either remote or adjacent marshes.

Results - St. Mary's River

A summary of the dominant vegetation within each study plot is given in Appendix G.

Near-shore (45 m) Transects

Several differences in overall abundance with respect to distance from shore and treatment group were found in the St. Mary's River study (Table 41). Two taxa, Typha and Equisetum, showed a significant relationship between abundance and distance from shore. Both tended to decrease in percent cover with increasing distance. Six taxa, including the two above, demonstrated a significant difference in abundance between treatment groups, but no general pattern in these differences emerged as half were more abundant in adjacent marshes and half were more abundant in remote marshes. Only one taxa, Equisetum, showed a significant interactive effect between treatment and abundance-distance profile, this was due to its complete absence in remote marshes.

Overall species richness per study plot ranged from 7.0 to 11.0, but mean richness per quadrat was similar in all four marshes examined. And, while there were no apparent differences in richness with respect to distance from shore or treatment group, there was a significant interactive effect (df=2, p=0.001). In adjacent marshes, richness nearly doubled from the first 15 m to the second, and then did not change, whereas, in the remote marshes, mean species richness progressively dropped with increasing distance from shore.

Shoreline Transects

Table 42 shows mean similarities among plots within each marsh. With the great variability among marshes, no obvious differences between remote and adjacent marshes are apparent. However, using mean values for each marsh, it appears that both remote marshes (X_{BC}=0.33) and adjacent marshes (X_{BC}=0.38) were much more similar to each other than were cross-treatment marshes (X_{BC} =0.15). Table 43 shows the within treatment vs. between treatment mean similarities, and indicates a significant difference (t=2.16, df=13, p=0.05)

Species richness was appreciably higher in the remote marshes (X=3.7) than in adjacent marshes (X=2.5) (Table 44).

Whole-marsh Transects

Very little "similarity" was found within or between treatment groups. Only six of the 66 pair-wise comparisons made revealed significantly "similar" vegetation characteristics (Table 47). Two of these involved marshes in different treatment groups while the remaining three involved marshes from within the same treatment group.

Table 40. Summary of Wilcoxon Matched-pairs Test for Yearly Variation[a] in Vegetation of Wetland Plots, Duluth.

Marsh and species tested	P value (two tailed)[b]
Hog Island	
Typha spp.	0.31
Sparganium eurycarpum	0.11
Sagittaria latifolia	0.51
Cyperaceae spp.	0.04[c]
Nemadji River	
Typha spp.	0.04[c]
Sparganium eurycarpum	0.58
Cyperaceae spp.	0.07
Allouez Bay #1	
Sparganium eurycarpum	0.72
Equisetum fluviatile	0.18
Sagittaria latifolia	0.14
Potentilla palustris	0.18
Cyperaceae spp.	0.59
Allouez Bay #2	
Sparganium eurycarpum	0.04[c]
Sagittaria latifolia	0.49
Potentilla palustris	0.89
Cyperaceae spp.	0.49
Allouez Bay #3	
Sparganium eurycarpum	0.53
Sagittaria latifolia	0.38
Cyperaceae spp.	0.61
Spirodella polyrhiza	0.59
Potentilla palustris	0.74
Allouez Bay #4	
Sagittaria latifolia	0.09
Menyanthes trifoliata	0.76
Cyperaceae spp.	0.85
Oliver Bridge	
Typha spp.	0.35
Sagittaria latifolia	0.24
Calla palustris	0.92
Cyperaceae spp.	0.42

Table 40 (concluded).

Marsh and species tested	P value (two tailed)[b]
Mud Lake	
Typha spp.	0.40
Sagittaria latifolia	0.45
Calla palustris	0.94
Cyperaceae spp.	0.47
Spirit Lake #1	
Typha spp.	0.91
Sparganium eurycarpum	0.47
Sagittaria latifolia	0.06
Calla palustris	0.57
Potentilla palustris	0.67
Cyperaceae spp.	0.10
Spirit Lake #2	
Typha spp.	0.44
Sparganium eurycarpum	0.17
Sagittaria latifolia	0.17
Calla palustris	0.04[c]
Potentilla palustris	0.95
Cyperaceae spp.	0.83
Spirit Lake #3	
Typha spp.	0.52
Sparganium eurycarpum	0.08
Calla palustris	0.67
Potentilla palustris	0.48
Cyperaceae spp.	0.72

[a]Tested dominant species in each marsh one at a time using % cover data on full marsh (100 m) transects; matched pairs were data for each quadrat for 1979 and 1980.
[b]Corrected for ties.
[c]Considered significant (at $p=0.05$ level).

Table 41. Summary of Two-way ANOVA Test for Differences in Plant Species Abundance in Near-shore Wetland Transects, St. Mary's River.

Species	Abundance with distance from shore[a]	Abundance with shipping status[b]	Interaction effect[c]
Typha spp.	p=.001 (-)	p=.001 (+)	n.s.
Equisetum spp.	p=.016 (-)	p=.007 (+)	p=.016
Carex spp.	n.s	p=.001 (-)	n.s.
Glyceria spp.	n.s	p=.001 (-)	n.s.
Galium spp.	n.s	p=.002 (-)	n.s.
Scirpus spp.	n.s	p=.001 (+)	n.s.

[a](+) indicates increase in abundance with increasing distance from water's edge. (-) indicates decrease in abundance with increasing distance from water's edge.
[b](+) indicates more abundant in marshes adjacent to shipping lanes.
(-) indicates less abundant in marshes remote from shipping lanes.
[c]Interaction between abundance/distance profile and shipping status.

Table 42. Within-marsh Shoreline Vegetation Similarity Index Values[a] for Six St. Mary's River Marsh Sites, 1980.

Marsh	Mean	S.D.	Range
<u>Remote</u>			
Whitehouse	0.85	0.13	0.67-0.99
Redhouse	0.60	0.18	0.35-0.81
Kemp's Point	0.84	0.08	0.75-0.99
<u>Adjacent</u>			
9-mile Road #2	0.93	0.04	0.87-0.99
9-mile Road #1	0.91	0.04	0.86-0.98
12-mile Road[b]	0.40	0.31	0-0.81

[a]Bray-Curtis similarity index values, based on 10 pairwise comparisons of the five plots in each marsh.
[b]Only four of the five plots had vegetation, therefore only six pairwise comparisons were made.

Table 43. Comparison Among Marshes of Mean Shoreline Vegetation Profiles,[a] St. Mary's River, 1980.

Group	n	Bray-Curtis Index value	Mean
Within remote	3	0.15	
		0.30	0.33
		0.53	
Within adjacent	3	0.20	
		0.37	0.38
		0.56	
Between treatments	9	0.00	0.15
		0.00	
		0.00	
		0.00	
		0.10	
		0.18	
		0.23	
		0.25	
		0.58	

[a]Mean values for all species in five plots were used to calculate each marsh value; then, all marsh pairwise comparisons were made.

Table 44. Species Richness of Herbaceous Vegetation on Shoreline of Wetland Plots, St. Mary's River.

Marsh		No. species[a]
Remote from shipping		
Whitehouse		2.2 ± 0.4
Redhouse		4.2 ± 1.6
Kemp's Point		4.6 ± 0.5
	Overall mean	3.7 ± 1.3
Adjacent to shipping		
9-Mile Road #1		3.0 ± 0.0
9-Mile Road #2		2.0 ± 1.6
12-Mile Road #3		2.4 ± 0.5
	Overall mean	2.5 ± 0.5

[a]Mean ± 1 standard deviation, based on five 1-m^2 plots in each marsh.

Table 45. Summary of Kendall's Tau[a] Comparisons of Vegetation in Wetland Plots, St. Mary's River.

Marsh	Marsh: Adjacent to shipping						Marsh: Remote from shipping					
	Mike's Landing Culvert	Mike's Landing #2	Flory's Fortress	12-mile Road #1	12-mile Road #2	12-mile Road #3	Whitehouse #1	Whitehouse #2	Whitehouse #3	Munuscong Dike #1	Munuscong Dike #2	Munuscong Dike #3
Adjacent												
Mike's Landing C.	--											
Mike's Landing #2	0.25	--										
Flory's Fortress	-0.37	-0.36										
12-mile Road #1	-0.33	-0.40	-0.20	--								
12-mile Road #2	-0.46	-0.24	-0.74	0.47[b]	--							
12-mile Road #3	0.00	-0.15	-0.08	0.09[b]	-0.24	--						
Remote												
Whitehouse #1	0.00	0.33[b]	-0.38	-0.56	-0.56	-0.34	--					
Whitehouse #2	0.08	0.11	-0.37	-0.23	-0.44	-0.18	0.42[b]	--				
Whitehouse #3	-0.04	0.08	-0.30	-0.13	-0.03	-0.05	0.23	-0.46	--			
Munuscong #1	0.15	-0.14	-0.11	-0.13	-0.44	0.38	-0.34	-0.24	-0.34	--		
Munuscong #2	0.20	0.38[b]	-0.37	-0.30	-0.20	0.19	-0.06	0.01	-0.68	-0.12	--	
Munuscong #3	0.01	0.10	-0.38	-0.19	-0.21	0.00	-0.28	-0.19	-0.14	-0.13	0.48[b]	--

[a]Based on mean % cover of all species present in at least one of two marshes being compared; zero values were assigned last place rank and Tau was correct for ties; data taken from interior (100m) transects, 1979.
[b]Signifies significant similarity at $p = 0.05$ level.

Colonial Nesting Bird Study - St. Mary's River

The objective of this portion of the breeding bird studies was to assess real and/or potential impacts of winter navigation upon colonial nesting birds and their habitats (gulls, terns, and herons) on the St. Mary's River. To do so, the nesting populations utilizing the U. S. portions of the river from Sault Ste. Marie, Michigan to DeTour, Michigan were censused during the 1979 and 1980 breeding seasons. In addition, plant community composition and colony site size (for island sites) were assessed at a number of locations. The results of this work were compared to similar data gathered during previous studies (1976 and 1977) of these colonies (Scharf 1978, Scharf et al. 1979).

Methods. Colony sites were located via aerial reconnaissance of the area area conducted at least twice during each nesting season. Previous knowledge of traditional nesting sites greatly facilitated this task. A "colony" included any area encompassing a group of nests each of which was no further than 100 m from its nearest neighbor. Thus nest clusters further than 100 m apart were considered separate colonies.

Breeding populations were estimated by censusing the nests present in each colony. With the exception of great blue heron colonies, all censuses were made via total ground counts of nests and eggs and/or chicks present at the peak of incubation. Heron colonies were censused from the air using a fixed-wing aircraft at low altitude. Subjective assessments of chick survival were made at selected common tern and ring-billed gull colonies. Common tern chick production was determined by banding chicks and checking for subsequent fledging or mortality at 10-12 day intervals. In ring-billed gull colonies, representative sub-sections of a given colony were monitored via visual estimates of survival.

The herbaceous and woody vegetation present in selected colonies were sampled and analyzed during both years of the study. Herbaceous plants were quantified using 1-m^2 quadrats located at 2-m intervals along straight-line transects. The length of the transects and therefore the number of samples taken varied with colony size. The maximum number of quadrats in a given colony was 20 and the minimum five. An estimate of percent cover to the nearest 5% and a count of the number of stems for each species within each quadrat were made. From these data the relative percent cover, relative density, and a composite importance value were calculated for each species for each transect. Importance values were calculated as before. Shrubs and trees were sampled using 16 m^2 (4 m x 4 m) quadrats located wherever clumps of of woody vegetation occurred. The measurements and calculations made were the same as for herbaceous vegetation.

All vegetation measurements were made shortly after the fledging period in August. Most species identifications were made in the field, but, laboratory microscopic examinations of samples were made in some instances. Gray's Manual of Botany, 8th edition (Fernald 1950) and Fasset's Manual of Aquatic Plants (Fasset 1975) were used. Most identifications were verified at Louisiana State University (Scharf 1978).

Changes in colony site (island) size were assessed subjectively. Oblique aerial photographs of each site were taken each year using "true color" transparency and a 35 mm camera. In addition, the width and/or length of some

sites was measured on the ground both years. These data were compared to to similar measurements made in 1976 and 1977 (Scharf et al. 1979).

Results. A total of 40 colonies, including great blue herons, herring gulls, ring-billed gulls, and common terns, were found during the investigation (Table 46). The total nesting populations of each species each year, including previous data compiled in 1976 and 1977, are presented in Table 47. A summary of the vegetation and other basic information regarding each colony is given in Appendix H.

Both great blue heron and herring gull colony locations remained quite stable during the five year period from 1976 to 1980. Of 17 herring gull colony sites used in 1976, only two were abandoned by 1980, and only six new sites were added (Table 48). No great blue heron colonies were abandoned during this period, but two additional sites were found. The latter two sites did not appear to be newly colonized sites, but rather were in remote areas and unknown prior to the present study. Thus, as found earlier for gulls and herons (Erwin 1978) colony turnover rates for these species were quite low. No major difference in turnover rates between the 1976-1977 and 1979-1980 periods was apparent (Tables 49 and 50). The overall stability of these populations in the region may reflect the fact that the majority of sites used by these two species are natural sites not especially susceptible to erosion, being situated well above waterline.

In contrast to the foregoing species, the common tern and ring-billed gull experienced very definite breeding habitat losses, with subsequent higher turnover rates (Table 48). Most of these losses occurred at colonies located on man-made (i.e., dredge deposition) islands. Seven of ten man-made islands with ring-billed gull or common tern colonies present diminished appreciably in size or were entirely eliminated (Table 51). The losses were due to several interrelated causes including high water levels (Table 52), periodic flooding of low-lying sites, and erosion. Shipping also had an impact as the wakes of passing ships definitely magnified the effect of the above factors, especially erosion. While this was not quantified, the effect was obvious during field observations of ship passages during the summer months. Those islands composed of exposed dredge cover of clay materials seemed most vulnerable.

The effects of winter ship passage on these sites are difficult to separate from those due to summer shipping. Of the 10 man-made sites with colonies present, all but one were exposed to both summer and winter shipping. A comparison of areal losses during 1976 and 1977 (winter shipping) to losses incurred during 1979 and 1980 (very limited winter shipping), would be instructive, but the data are not continuous at given sites. Water level changes which occurred during this time further complicate interpretation. It is apparent that losses occurred during both periods, but it is not possible to determine the extent to which winter traffic contributed to the problem, nor is it evident what proportional contribution shipping in general made compared to other causes (e.g., high water levels).

Colony turnover rates actually seem to indicate that there was more impact during the period with no winter shipping (1979 and 1980) (Tables 49 and 50). During this time the turnover rate for common terns was 0.60 while following

the active shipping winter of 1977, the turnover rate was quite low. However, water levels in 1977 were appreciably lower than in other years, perhaps reducing the impact of shipping.

Overall, natural island sites showed far less erosion. Many of these have rocky beaches and lie higher above water level than do the man-made sites. However, both Little Cass Island and Harbor Island Reef lost approximately 60% to 80% of their former surface area. Andrews Island also lost a significant amount of area. While the above losses were not quantified through actual measurements, they were marked enough to be obvious to fir'' personnel.

Both the common tern and ring-billed gull underwent habitat utilization changes during the 1976-1980 period. The ring-billed gull increased its nest density and invaded "marginal" habitats. For example, on Southwest Neebish Island-I, as suitable nesting habitat eroded away, nest density from 0.49 nests per m^2 (1977) to 1.6 nests per m^2 (1979). On most islands, the area remaining after erosion was not as suitable as previously, and in these cases ring-bills nested in formerly unoccupied areas vegetated with woody plants (usually sand bar willow, Salix interior). Mortality was high in these areas as many birds were caught in the forked willow branches. Ring-bills also colonized areas of reeds (Phragmites communis). Part of reason for the observed changes in density or microhabitat could have been caused by population increases (Table 47) as well as habitat erosion.

The apparent effects of breeding habitat losses on the common tern were twofold. Firstly, the breeding population dropped markedly from 1976 to 1977 (Table 47). Secondly, although the number of initial breeding attempts remained essentially the same after 1977, the birds began using more colony sites (Table 46). Common terns made repeated nesting attempts on washed-over colonies and success seemed low.

Although two very small colonies, Little Cass Island and Southeast Boundary Island, had a fledging rate of over 1.0, the fledging rate at two larger and more significant colonies, Northwest Sugar Island and Mid 6-Mile Island, was only about 0.5 per nest. This is substantially below replacement rates proposed by Nisbet and Drury (1972) and Morris et al. (1980).

In addition to erosional losses, breeding habitat for common terns was reduced by plant successional changes. In particular, increased density of perennial herbs and woody plants such as willow and Populus spp. limited the available suitable nesting area.

There is no evidence that reduced common tern populations and breeding success are a result of the concomitant increase in ring-billed gulls on the St. Mary's River. Within the river area, there are only five colony sites where both ring-bills and common terns nested. In each case the two species are well-separated with terns utilizing bare rocky or sandy areas. In May 1980, a new sandbar formed on Little Cass Island, and common terns subsequently nested and took over a former ring-billed gull breeding area. However, in May 1977, when falling water levels exposed considerable additional bare area on dredged material cones, the terns did not utilize the newly available habitat despite the fact that a large colony at Southeast Neebish Island had been lost.

Table 46. Colonial Nesting Bird[a] Summary of Number of Nests St. Mary's River 1976-1980.

Site[b]	Latitude	Longitude	Total Number of Nests 1976	1977	1979	1980
St. Mary's River Locks Island	46°30'	084°20'	--	--	336 HG	380 HG
Southeast of Boundary Island	46 29	084 17	--	--	--	15 CT
Boundary Island	46 29	084 17	--	--	--	2RBG, 43 CT
Northwest Sugar Island[a]	46 27	084 16	81 CT	1 HG, 21 CT	1 HG, 18 CT	38 CT
West Sugar Island II[a]	46 26	084 15	0 CT, 0 HG	1 HG, 44 CT	20(80) CT	0
West Sugar Island I[a]	46 26	084 15	139 CT	116 CT	22 CT	0
Mid 6 Mile Point Island[a]	46 25	084 15	--	--	--	62 CT
Upper Nicolet	46 26	084 14	--	--	16 HG	5 HG
South Upper Nicolet	46 26	084 14	--	--	1 HG	1 HG
Gem Island	46 26	084 11	43GBH, 27 HG	33GBH, 28 HG	47GBH, 22 HG	38GBH, 5 HG
Rock Island	46 23	084 09	23GBH, 53 HG	27GBH, 48 HG	25GBH, 52 HG	24GBH, 13 HG
Shoal S. of Hen & Chicken			--	--	--	1 HG
Southeast Nebbish Island[a]	46 14	084 07	1 HG, 49RBG, 136 CT	55RBG, 45 CT	1 HG, 8RBG	0

Table 46 (continued)

Site[b]	Latitude	Longitude	Total Number of Nests 1976	1977	1979	1980
Squaw Island	$46^{o}02'$	$083^{o}54'$	108 HG	91 HG	43 HG	60 HG
West Pipe Island Twin	46 01	083 54	138 HG	145 HG	62 HG	120 HG
East Pipe Island Twin	46 01	083 54	79 HG	100 HG	128 HG	65 HG
Harbor Island Reef	46 03	083 47	inundated	2 HG, 192RBG	4RBG	2 HG, 6 CT
Cedar Island	46 06	083 46	--	--	56GBH	38GBH
Propeller Island	46 05	083 45	68 HG	52 HG	21 HG	30 HG
Arrow Island	46 01	083 49	21 HG	33 HG	8 HG	12 HG
Bow Island	46 02	083 50	7 HG	0	0	0
Bacon Island	46 03	083 50	196 HG	192 HG	23 HG	27 HG
Macomb Island Dock[a]	46 04	083 52	5RBG	0	0	0
Andrews Island	46 03	083 53	1,815RBG	0	620RBG	1,377RBG
Little Cass Island	46 04	083 54	7 HG	5 HG, 2,063RBG	4 HG, 352RBG	7 HG, 8 CT 279RBG
Moon Island[a]	46 13	084 10	18 HG, 982RBG	7 HG, 1,673RBG	3 HG, 2,957RBG	3 HG, 3,564RBG
Southwest Neebish Island[a]	46 13	084 10	1,263RBG	2,398RBG	I- 242RBG II-2,041RBG III- 43RBG	I- 0RBG II-3,189RBG III- 64RBG

Table 46 (concluded)

Site[b]	Latitude	Longitude	Total Number of Nests 1976	1977	1979	1980
Kemps Point Island[a]	46°11'	084°11'	--	--	--	23 CT, 1 HG
Steamboat Island	46 10	084 12	24 HG	16 HG	7 HG, 2 CT	17 HG
Roach Point	46 12	084 10	--	--	33GBH	39GBH
Two Tree Island	46 12	085 05	42 HG	46 HG	33 HG	40 HG
Round Island	46 06	084 01	39GBH	39GBH	43GBH	42GBH
Love Island	46 07	083 58	--	--	--	1GBH
Bass Reef Island	46 06	084 00	47 HG	43 HG	19 HG	14 HG
South of South Bass Reef	46 06	084 00	--	--	--	3 CT
South Bass Reef	46 07	084 00	--	--	23 CT, 3 HG	2 HG
North Sweets Island	46 02	083 00	--	--	10 CT, 62RBG	3 CT, 18RBG
Watson Reef Ruins[a]	46 00	083 54	53 CT	20 CT	18 CT	45 CT
Frying Pan Island	45 59	083 54	0	0	1 HG	0
Cable Island[a]	46 04	083 34	23 HG	23 HG	17 HG	21 HG

[a]Signifies man-made islands.
[b]HG=herring gull; RBG=ring-billed gull; CT=common tern.

Table 47. Total Number of Nests of Colonial Nesting Birds on the St. Mary's River, 1976-1980.

Species	Year			
	1976[a]	1977[a]	1979	1980
Common tern	409	246	173	246
Ring-billed gull	4,114	6,326	6,267	8,493
Great blue heron	105	99	204[b]	182[b]
Herring gull	857	834	863[b]	826[b]

[a]From Scharf et al. (1979).
[b]Significant new colonies found.

Table 48. Colony Site Turnover Rates (T) Between 1976 and 1980 on the St. Mary's River.

Species	No. colonies (1976)	No. colonies (1980)	No. colonies not re-used	No. new (1980)	T[a]
Common tern	4	10	2	8	0.65
Ring-billed gull	6	6	2	2	0.33
Great blue heron	3	5	0	2[b]	0.16[b]
Herring gull	17	21	2	6	0.20

[a]Turnover rate T taken from Erwin et. al (1981) where:

$$T = \frac{1}{2}\frac{S_1}{N_2} + \frac{S_2}{N_2}$$

where: S_1 = number of original colonies abandoned

S_2 = number of new colonies initiated

N_1 = total number of colonies in orignial year

N_2 = total number of colonies in most recent year.

[b]The "new" colonies may have been missed in earlier censuses. If so, T=0.

Table 49. Colony Site Turnover Rates (T) Between 1976 and 1977 on the St. Mary's River.

Species	No. colonies (1976)	No. colonies (1977)	No. colonies not re-used	No. new (1977)	T[a]
Common tern	4	5	0	1	0.10
Ring-billed gull	6	6	2	2	0.33
Great blue heron	3	5	0	2[b]	0.20[b]
Herring gull	17	17	2	2	0.11

[a] Turnover rate T taken from Erwin et. al (1981) where:

$$T = \frac{1}{2}\frac{S_1}{N_2} + \frac{S_2}{N_2}$$

where: S_1 = number of original colonies abandoned

S_2 = number of new colonies initiated

N_1 = total number of colonies in orignial year

N_2 = total number of colonies in most recent year.

[b] See footnote b on Table 50.

Table 50. Colony Site Turnover Rates (T) Between 1979 and 1980 on the St. Mary's River.

Species	No. colonies (1979)	No. colonies (1980)	No. colonies not re-used	No. new (1980)	T[a]
Common tern	6	10	3	7	0.60
Ring-billed gull	8	6	3	1	0.27
Great blue heron	5	6	0	1	0.08
Herring gull	21	21	3	3	0.14

[a]Turnover rate T taken from Erwin et. al (1981) where:

$$T = \frac{1}{2}\frac{S_1}{N_2} + \frac{S_2}{N_2}$$

where: S_1 = number of original colonies abandoned

S_2 = number of new colonies initiated

N_1 = total number of colonies in orignial year

N_2 = total number of colonies in most recent year.

Table 51. Comparison of Island Dimensions[a] for Colonial Sites on the St. Mary's River Suffering Areal Losses from 1976 to 1980.

Location	Shipping status[b]	Length and/or width (m)			
		1976	1977[c]	1979	1980
Northwest Sugar Island	S,W	18.5 x 17.0	--	18 x 16	18 x 16
West Sugar Island I	S,W	42	--	40	40
West Sugar Island II	S,W	--	52 20 37	36 20 24	--
Moon Island	S	--	48	40	40
Southwest Neebish Island I	S,W	--	46 x 20	26 x 6	gone
Southwest Neebish Island II	S,W	22	--	20	18
Southwest Neebish Island III	S,W	--	--	24 x 18	22 x 12

[a]Various linear dimensions were repeatedly measured each year.
[b]S = near summer shipping channel, W = near winter shipping channel.
[c]In 1977 most dimensions increased due to lowered water level on river (See Table 54).

Table 52. Mean Water Level of St. Mary's River, 1976-1980.

Year	12-month mean water level[a] above sea level (ft)
1976	580.545
1977	579 534
1978	580.170
1979	580.710
1980	580.268

[a]From U. S. Army, Corps of Engineer's data, U. S. slip station; low water datum was 577.80 ft.

Summary of Breeding Birds and Their Wetland Habitats (Unit 3)

Study plots were established in marshes in the Duluth-St. Louis River estuary and along the St. Mary's River to examine the potential effects of shipping disturbances to wetland vegetation and to their associated avian fauna. Equal numbers of plots "remote" from shipping lanes and plots close to lanes were established as a "side-by-side" comparison.

The results of the breeding bird censuses indicated that the red-winged blackbird is the predominant species in both study areas, with smaller numbers of long-billed marsh wrens, swamp sparrows, yellowthroats and others.

In both areas, there was substantial yearly and plot-to-plot variation in breeding densities but there were no significant differences due to either year or location (relative to shipping). Species richness was very low in most marsh plots, with means per plot ranging from 1.0 to 2.7 in Duluth, from 1.3 to 2.0 in the St. Mary's.

Wetland vegetation analyses were performed in both areas using percent cover by species as the primary variable. Three transect types were used. Results of the near-shore (45 m) transects showed that in both areas, six of 11 taxa showed a "treatment" (location) effect with some species more abundant in "remote" plots, others in "adjacent" plots. Zonation patterns showed similarity between the two areas. Remote marshes had a monotonically decreasing species richness with distance from shoreline. "Adjacent" marshes, however, either showed no change in richness with distance (Duluth) or richness increased in the intermediate zone.

"Whole-marsh" (100 m) transect results indicated that, when comparing marshes within and between treatment groups, the predominant pattern in both areas was high heterogeneity (low similarity) in pairwise comparisons. Treatment effect had little influence in St. Mary's River marshes but, in the Duluth area, similarity among remote marshes was much higher than among adjacent marshes and was higher than would be predicted by chance.

Analyzing the shoreline edge vegetation again yielded differences between study areas. In Duluth, comparing marshes showed no major similarity value differences among remote or treatment marshes or between the two types (mean similarity values in the 0.30 - .35 range). However, in the St. Mary's, there was much higher similarity within treatment groups (BCI values 0.33 and 0.38) than between remote and adjacent marshes (0.15).

The overall impression generated by the wetland vegetation results in the two study areas is one of great heterogeneity both within and between marshes. These appear to be no neat "assembly rules" (Diamond 1975) suggesting internally-organized communities with a high degree of species associations. Similar results were obtained by Raup (1975) in his analysis of shore vegetation transects in the Athabaska-Great Slave Lake region of Canada. He found a high degree of "habitat flexibility" among many of the plants, with the fibrous-rooted perennials (such as the dominant *Sagittaris* spp. and *Scirpus* spp. in the Great Lakes) showing the most versatility. He suggested that chance, in part, plays an important role in where species become established. His findings seem to parallel those reported here.

The colonial bird studies on the St. Mary's River revealed that both Common Tern and Ring-billed Gull nesting habitat may be declining markedly. Significant habitat losses occurred on a number of man-made islands (dredged material) over a four-year period. At present, it is not possible to separate the erosional effects of summer from winter shipping.

The rate of colony site change ("turnover") for the two above-mentioned species was higher than for the Herring Gull and Great Blue Heron, species which nest on more stable substrates. The only species whose numbers have declined in the St. Mary's region is the Common Tern. Whether this is due primarily to the reduction in nesting habitat is uncertain. In contrast, Ring-billed Gull numbers have increased markedly.

GREAT LAKES BEACHED BIRD SURVEYS (STUDY UNIT 4)

This section presents the work of the Great Lakes Beached Bird Survey as it relates to the potential effects on bird populations of an extended navigation season on the Great Lakes. The Great Lakes Beached Bird Survey (GLBBS) was initiated in 1977 to document the extent and seasonal occurrence of bird mortality on the Great Lakes. Beaches are surveyed by volunteers at monthly or bimonthly intervals to record numbers of beached (dead or dying) birds. Beginning in December 1979 the numbers of live waterbirds and ice conditions were recorded at survey routes also. Some surveys were located in areas affected by shipping or thermal discharges from industrial plants. To provide additional data on bird use of these areas, special counts of waterbirds were made at selected harbors and power plants in the winters of 1979-80 and 1980-81.

Results are reported in three sections: information obtained from surveys on the distribution of waterbirds on the Great Lakes in the winters of 1979-80 and 1980-81, results of beached bird surveys from 1977 up to April 1981, and results of special waterbird counts at harbors and thermal discharge sites. A synopsis of results of the first three years of GLBBS and an examination of the relation of beached bird numbers to live waterbird numbers are also given.

Methods

Beached Bird Surveys. Beached bird surveys were conducted by volunteers who chose a stretch of beach approximately 4 km in length to survey once or twice per month. Instructions and forms were provided (see Appendix I). Volunteers first registered their survey beach, providing information on the characteristics of the beach, including length and width, substrate, vegetation, human use and proximity of concentrations of birds. Beaches were surveyed at least once a month, recording information on species, age, sex, condition, and cause of death. An optional procedure for counting live waterbirds present at survey routes was conducted by most participants. For our purposes, "waterbirds" include loons, grebes, cormorants, herons and egrets, swans, geese, ducks, gallinules, coots, rails, shorebirds, gulls, and terns. Depending on the length of the beach, from two to four spot counts were made of all waterbirds in view that were identifiable to family using binoculars. The number of each species (or family if not identifiable to species) in each of several activity categories was recorded on standard forms. At the location of the count, the participant recorded the width of the shoreline ice and the extent of the open water areas. Both beached bird and live waterbird count reports were forwarded three times a year to the survey organizer who analysed the results.

Figure 32 shows the location of regular survey routes in 1977-78, 1979, and 1980. On 31 August 1979, before the start of the present project, there was a predominance of survey routes on the north shore of Lake Ontario, very few on Lake Michigan, and none on Lake Superior. Efforts to recruit additional participants more than doubled the number over the next year. Surveys were done at 54 survey routes in 1979 and at 109 survey routes in 1980. Coverage was increased on Lake Michigan (21 new routes), the Detroit River (5 routes), Lake Superior (5 routes), and Lake Huron (11 routes).

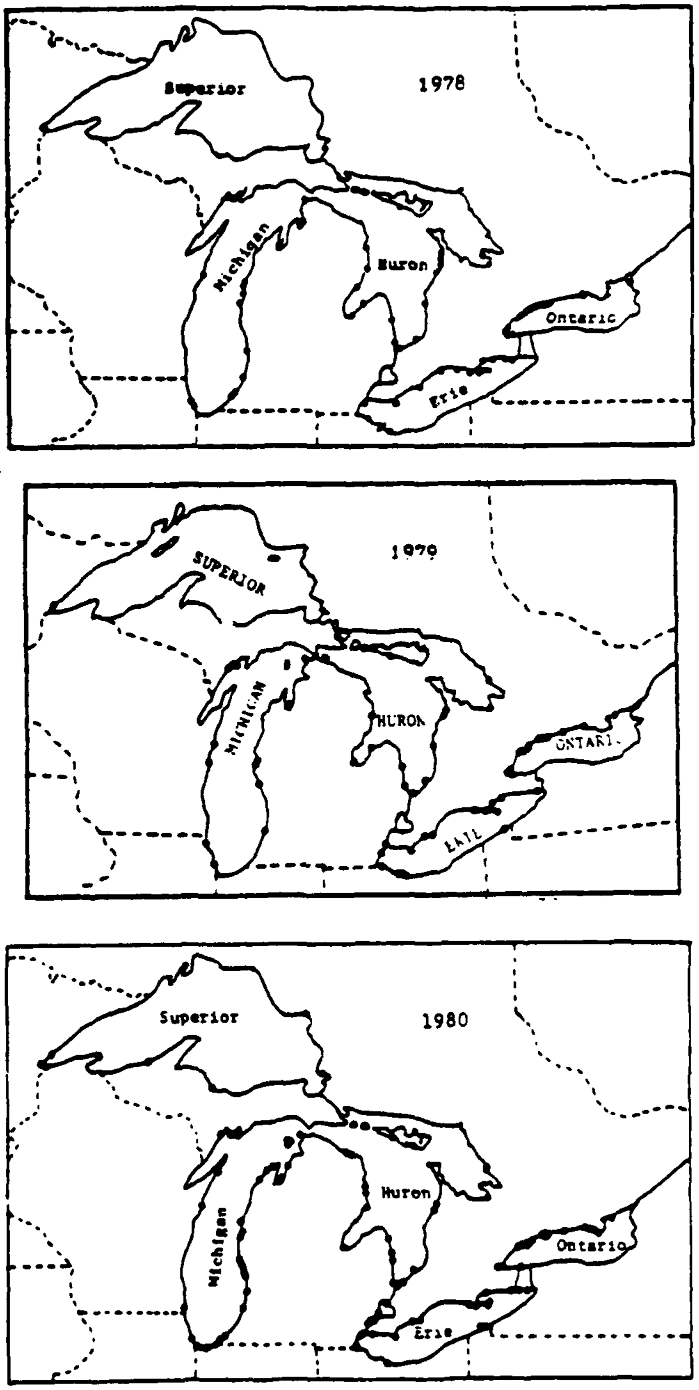


Figure 32. Distribution of GLBBS survey routes in Nov. 1977-1978, 1979 and 1980.

Despite efforts to obtain volunteer survey coverage of urban areas and harbors, new survey routes were nearly all in rural or cottage areas. Survey coverage was obtained at six generating stations on Lakes Superior, Michigan, Huron (2), the Detroit River, Lake Ontario, and at a harbor and steel plant on Lake Ontario.

For purposes of analysis, mean monthly values of beached birds per kilometer were calculated for each lake by dividing the number of birds found by the total length of shoreline surveyed. When more than one survey was done at a survey route in the month, surveys were averaged for that route before entering into the calculation of the mean. Thus, if one bird was found on two surveys of a three km route, the values 0.5 birds and three km would be used for the route. Similarly, in calculating the monthly mean for all lakes, the total number of birds found (actually the sum of birds per survey) was divided by the total length of the routes surveyed. To calculate yearly 'beaching rates' (birds per km) on each lake or all lakes, the monthly values of the sum of birds per survey and total lenth of routes were summed and then divided. Therefore, months were weighted by the amount of shoreline surveyed. Seasonal values, e.g., January-April, were calculated similarly. The above analysis was also done for the groupings of landbirds, waterbirds, ring-billed gulls, herring gulls, and ducks.

Live Waterbird Counts (LWC). For each month, the average number of birds of each species per LWC at a survey route was calculated. Thus, if two surveys were done at a route in a month, each with three LWC's, the total number of birds recorded on all counts was divided by six to get the birds per count value for the route. Route values were averaged to produce lake and month means. Again, for all lakes, survey route data were pooled, so that lakes were not weighted equally. In grouping months (to look at seasonal waterbird numbers), monthly values were averaged for a two or four month period, thus weighting months equally. However, in relating yearly values of birds on LWC's to total number of beached birds or to beached birds per km, the mean birds per count value for the year was calculated by pooling all counts rather than by averaging monthly values. This was done so that, for both variables, months were in effect weighted by the amount of survey coverage.

To convert values of numbers of birds on LWC's to number of birds per km, it was necessary to estimate the length of shoreline involved in live waterbird counts (which are spot counts). This was estimated by taking a number of measurements of the maximum distance at which birds are identifiable to family using binoculars, which defines the count area. Measurements were taken at several locations and under a variety of conditions, but all were taken by the same observer. The average of measurements of the length of shoreline involved in a LWC was reduced by 5% (an arbitrary conservative figure) to account for the fact that, since the count area is circular, the offshore "transect" is less than the length along the shoreline.

The final conversion factor arrived at is 1.0 birds per count = 0.62 bird per km (or 1.0 birds per mile). For reasons explained, the accuracy of this conversion factor is unknown. Although the correction factor is somewhat arbitrary, the relative magnitude of count totals should be useful.

Special Counts at Harbors/Power Plants. To obtain additional information on the use of harbors and warm water outflow areas by wintering waterbirds, special field trips were made both winters to determine bird use of thermal outflows (mainly power plants) and harbors on Lake Michigan, Erie, and Huron and the Detroit and St. Clair Rivers. At each site, all waterbirds within view were counted using a 20X spotting telescope. Ice conditions and their relation to the harbor or warm water outflow, shipping, and to the birds present, were also recorded.

Other analyses. For the months of December to April, information on ice conditions given on LWC report forms was used to calculate the percentage of survey routes on each lake with complete ice cover. Since one survey of a route can have counts with and without complete ice cover, values used for each route in calculating the percentage were the proportion of count sites during the month at which there was a complete ice cover. Thus, if one route had complete ice cover, and another route had complete ice cover at one of two count sites, the average percentage complete ice cover for the two routes is 75%.

Several procedures were carried out using beached bird data in its raw form. A tally of all beached birds, most frequently beached birds, a cause of death tally, and age analysis of gulls were done using all beached birds equally (i.e., before averaging birds found on more than one survey in a month at a route).

Results and Discussion

The following deals mainly with results from the winter and early spring periods of 1979-80 and 1980-81. First, a brief summary of results of the first three years of GLBBS is presented. Complete results are published in annual reports of the survey each year by Long Point Bird Observatory.

Beached Bird Surveys, November 1977 to December 1980. In the three survey periods of November 1977 to December 1978, 1979, and 1980, beached bird surveys were conducted at 56, 54, and 109 survey routes respectively (Fig. 32). The total length of beaches averaged 197.3 km for the first two periods, which represents 1.2% of the Great Lakes shoreline, and was 341.3 km in 1980 or 3.3% of the Great Lakes shoreline.

In the three periods, the number of beached birds found was 1295, 1416, and 1121, respectively. At least 140 species were represented. Table 53 shows the most frequently beached birds. Ring-billed gulls and herring gulls made up about half of beached bird numbers. Age data for beached gulls indicates high numbers of hatching year birds (see Tables 54 and 55). The ratio of beached herring gulls to ring-billed gulls is approximately 1:2 for the two years, which is considerably less than the ratio of the nesting populations of the species on the Great Lakes (estimated at 1:5, D.V. Weseloh, pers. comm.).

The average number of birds found per km surveyed was 0.97 birds per km in 1978, 1.14 in 1979, and 0.51 in 1980. The beaching rate in 1980 was lower for landbirds, waterfowl, ring-billed gulls, and herring gulls. A marked decrease in beached gull numbers occurred only on Lakes Ontario and Huron. Age data for beached gulls indicates that the decline for both species

Table 53. Most Frequently Beached Birds from 1978 to 1980.

Species	No. found	Percent of total 1978	1979	1980
Ring-billed gull	1215	25.8	39.4	28.0
Herring gull	651	18.4	13.6	19.7
Unidentified gull	224	6.6	2.9	8.7
Oldsquaw	141	4.1	4.2	2.6
Mallard	123	1.7	5.6	2.0
Blue jay	107	4.6	2.3	1.2
Unidentified duck	90	1.9	2.2	1.2
White-winged scoter	79	2.0	0.8	3.6
Common flicker	72	2.0	0.7	3.2
Unidentified passerine	58	0.9	2.8	0.6
Total	2760	72.0% of 3834 found		

Table 54. Age Composition of Beached Ring-billed Gulls.

	1979		1980	
	No.	As % of aged birds	No.	As % of aged birds
Hatching year	392	77	129	45
Second year	27	5	56	20
After second year	31	6	41	14
Third year	22	0.4	5	2
After third year	18	4	28	10
After hatching year	36	7	27	9
Total aged	506	100	286	100
Unaged	51		28	
Total found	557		314	

Table 55. Age Composition of Beached Herring Gulls.

	1979		1980	
	No.	As % of aged birds	No.	As % of aged birds
Hatching year	66	40	59	31
Second year	24	15	26	14
Immature			3	2
After second year	9	6	7	4
Third year	16	10	21	11
After third year	27	17	36	19
Fourth year			3	2
After fourth year			13	7
After hatching year	21	13	23	12
Total aged	134	100	191	100
Unaged	58		30	
Total found	192		221	

mainly involved hatching year birds. Production of young was apparently unchanged in 1980, and our results were interpreted as evidence that the mortality rate of juvenile gulls on Lakes Ontario and Huron (lakes with the largest breeding populations) was lower in 1980 than in the previous year.

The numbers of beached birds found per km followed distinct seasonal patterns with predictable peaks in spring and fall. The beaching rate was very low in January and February when much of the shoreline was iced-in. Variations in the pattern for different groups of birds (landbirds, waterbirds, ring-billed and herring gulls) are shown in Figure 35. Landbirds show a prominent peak in the spring and a much smaller one in fall, while beached waterbirds were more numerous in the fall than the spring. Ring-billed gulls, which made up a large proportion of beached waterbirds, were found in their greatest numbers in late summer, reflecting high mortality of juvenile birds. The beaching rate of herring gulls remained high in November and December, while the beaching rate declined for ring-billed gulls, which leave the Great Lakes in large numbers in late fall. Oldsquaw, which come south to winter on the Great Lakes, peaked in the spring.

Statistical analyses were performed to test for correlations between numbers of beached birds found per km shoreline and a number of other variables. The major "effects" considered were: lake (or river) region (n=16) (See Aerial Surve Section Shore maps) year, month, "effluent" (discharge presence), colony proximity, navigation situation (near harbors or ship channels), urbanization (3 levels), and route number (n = 229), marsh proximity (2 levels), and hunting (near duck hunting area or not). The summary of analyses of variance are shown in Table 56. Of the eleven variables, all but "marsh proximity" were significant in explaining variation in beached bird numbers. However, a high degree of multicollinearity among the variables makes interpretation difficult. A correlation matrix of the independent variables indicated that about 2/3 of the cells were correlated at the $p \leq 0.05$ level.

When beached gulls were treated separately from beached waterfowl, the results showed several differences. The two factors "explaining" most of the variation in waterfowl numbers were hunting areas nearby and "year". For gulls, "lake" and "region" yielded the highest F values. Lake Ontario had the largest number of beached waterbirds per km, Lake Superior the lowest.

Stepwise regression analyses were also run with beached bird, beached gulls, and beached waterfowl per km as the dependent variable. Even though a number of variables were significant ($p \leq 0.05$), predictive powers of the equations were very low with r^2 values only in the 0.10 to 0.12 range.

In general, the numbers of beached gulls per km were relatively high on Lakes Ontario and Erie, varying seasonally with peaks in December and lowest counts in January-February (Fig. 36). Beached waterfowl densities were higher on Lakes Michigan and Ontario, with seasonal peaks found in April. The proximity of shipping lanes or active winter shipping harbors had nonsignificant effects upon the density of beached birds found. The presence of a thermal or industrial outfall had a positive effect on beached bird numbers but the outfall factor was intercorrelated with lake and urbanization effects.

Table 56. Results of Analysis of Variance Showing Effects of Ten Variables on Numbers of Beached Birds/km.

Source	F value	P level
Hunting	22.8	< .01
Year	19.3	< .01
Month	12.1	< .01
Effluent	11.2	< .01
Urbanization	10.3	< .01
Colony proximity	10.0	< .01
Lake	9.9	< .01
Region	8.3	< .01
Navigation	6.1	< .01
Route	5.2	< .01

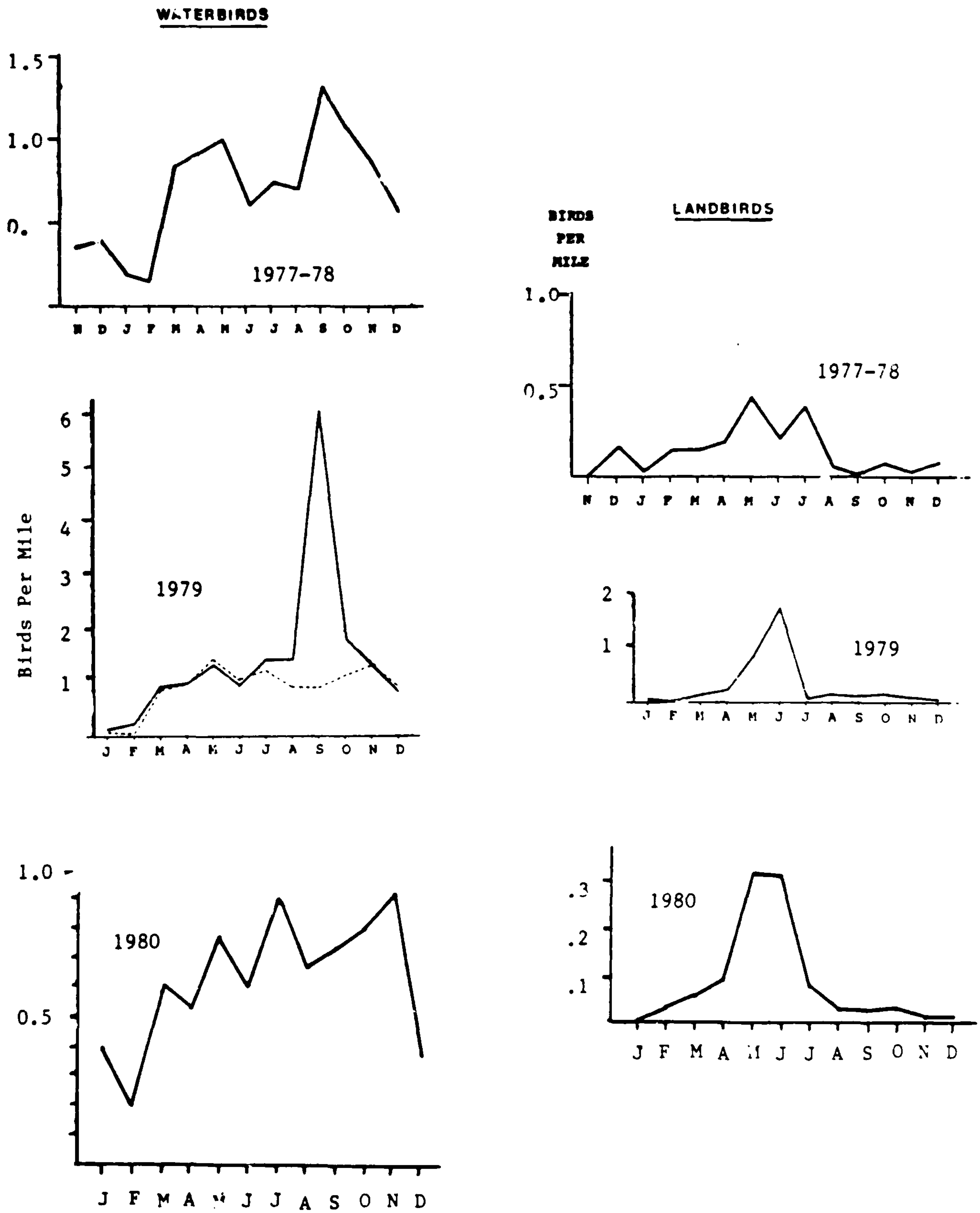


Figure 33. Seasonal occurrence of beached birds on the Great Lakes, for waterbirds and landbirds.

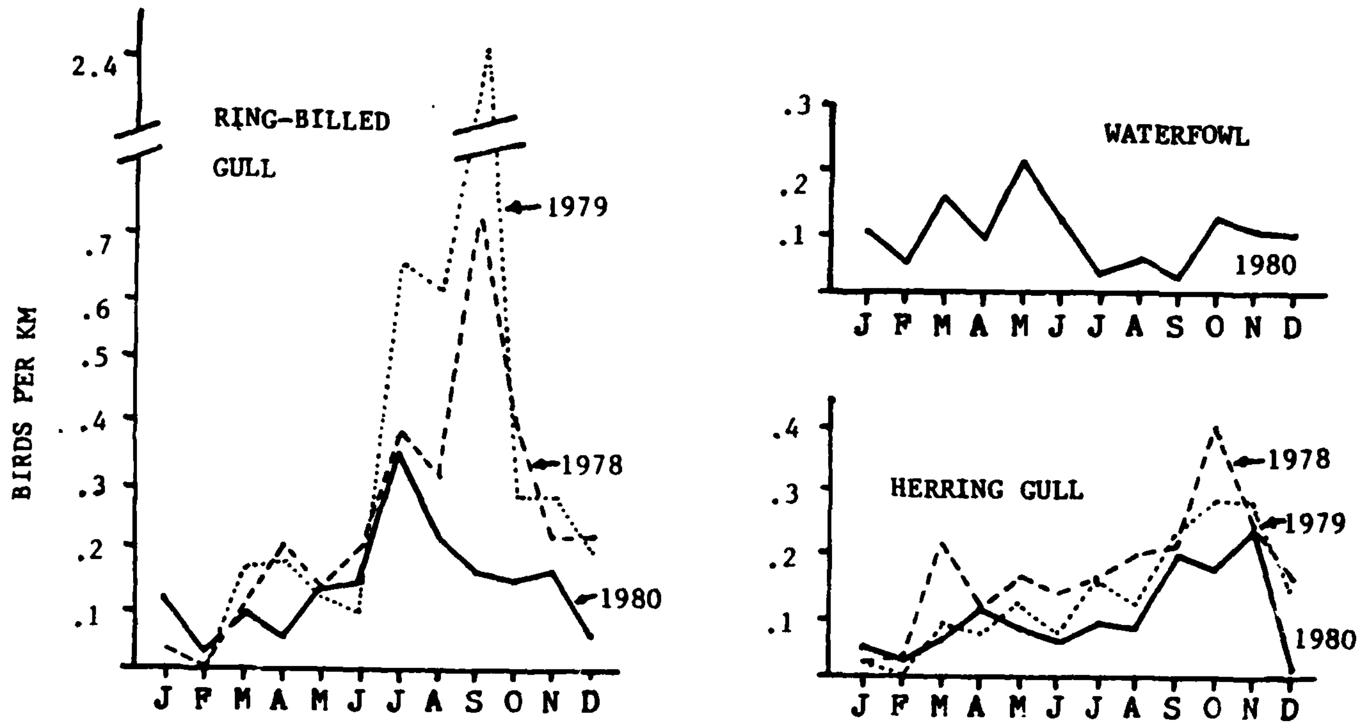


Figure 34. Seasonal occurrence of beached Ring-billed Gulls, Herring Gulls and waterfowl on the Great Lakes.

Beached waterfowl numbers showed more yearly variation than did gulls. In particular, during the 1977-78 period, there was significant mortality of oldsquaw and white-winged scoters. In the most recent two years, however, waterfowl numbers were fairly similar but numbers of gulls found on beaches declined by 28%.

The cause of death was recorded for 13% of birds found on surveys (Table 57). Cause of death usually was not apparent on external examination of the bird, and the difficulty was increased by the decomposed or dessicated state of most carcasses. Apparent starvation was the most frequent cause given, followed by deaths attributed to severe storms, gunshot wounds, and drownings in commercial fishing nets. There were a number of accidental deaths, mostly collisions with man-made or natural structures and in particular hydro-towers or wires. "Killed by predator" was often listed, but this cause is suspect as it is difficult to distinguish from the effects of scavenging. Thirty-one birds were found either entangled in fishing lines or with fish hooks embeded in their bills and several birds were found entangled in plastic 6-pack can holders. Each year, several large kills of migrating passerines (up to 62 birds in one survey) were noted on surveys done in the spring and early summer, with the majority occurring in southern Lake Michigan. These were associated with recent severe storms in the locality of the die-off, and must represent a small proportion of the numbers lost to storms during the migration periods. While only three oiled birds were found in 1979 and four in 1980, 23 were reported in 1978, most on a single survey at Point Pelee, Lake Erie, on 21 May. Along this three km survey route, 20 oiled birds were found including common terns, unidentified terns, gulls, and mergansers, and an unidentified duck and bird. The source was believed to have been a plant near Detroit which accidentally released oil. Other locations in which oiled birds have been found are Prince Edward County, Toronto Islands, and the St. Clair River, all in Ontario.

Live Waterbird Counts and Their Relation to Beached Bird Numbers (non-Winter). Counts of live waterbirds were done at 89% of survey routes in 1980. Table 58 shows the relative numbers of the most numerous species in the May-August and September-December periods. These results reflect the uneven distribution of survey routes and the fact that an occasionally large count of birds has a great effect on the mean (due to the small sample size of survey routes). Specific cases of this in the period of January to April are noted in the next section. In May, a count of 5000 Bonaparte's gulls at a Lake Huron survey route inflated the May-August value. On 14 December, single counts of 1300 Canada geese, 25,000 ring-billed gulls, and 5000 herring gulls greatly increased the September-December values for these species.

Results of the first year of live waterbird counts were compared with beached bird results in several ways. Regional differences in numbers of live birds present at survey routes were apparent, and corresponded roughly to regional variations in beached bird numbers ($r = 0.69$, $p > 0.05$). Table 59 compares lakes in the ratio of the beaching rate to the mean number of birds per km. Beaching rates of ring-billed gulls and waterfowl are strikingly high on Lake Michigan in relation to numbers of live birds. We lack evidence, but higher losses to commercial fishing operations or a higher incidence of disease are possibilities. Die-offs of oldsquaw and white-winged scoters have been noted on surveys on Lake Michigan as on other lakes, and the incidence of the diseases that affect these or other ducks (e.g., *Spheriotremea globulus*,

Table 57. Cause of Death Recorded for Beached Birds[a] Found From 19 November 1977 to 31 December 1980.

Cause of death		No. of birds
Apparent starvation/disease		118
Gunshot wounds		88
Storm/tornado		61
Killed by predator		58
Tangled in gill nets		41
Oiled		30
Hit hydro towers or wires		24
Tangled in fishing line		21
Hit rocks, car, oil tank or bridge		10
Fishhook embedded in bill		10
Broken neck		8
Botulism		4
Caught in plastic 6-pack holder		4
Frozen in ice		4
Pesticide/herbicide poisoning		4
Collided with cliff during storm		3
Killed by commercial fishermen		2
Drowning		2
Lighthouse kill		2
Plastic mesh wound around head & legs		1
Caught in string		1
Leg entangled in plastic bag		1
Internal parasites		1
Hung itself on tree		1
Other		2
	Total	501

[a]Cause of death reported for only 501 (13.4%) of 3746 birds.

Table 58. Most Numerous Species on Live Waterbird Counts (LWC), May to December 1980.

May - August		September - December	
Species	Mean no. per count	Species	Mean no. per count
Ring-billed gull	96.0	Unidentified gull	93.4
Herring gull	46.8	Ring-billed gull	79.0
Unidentified gull	15.3	Herring gull	27.1
Bonaparte's gull	14.5	Canada goose	10.6
Common tern	1.8	Unidentified duck	8.4
Mallard	1.2	Scaup, spp.[b]	5.9
Scaup, spp.[a]	0.9	Canvasback	4.2
Red-breasted merganser	0.8	Mallard	3.6
Canada goose	0.7	Red-breasted merganser	3.5
Common merganser	0.3	Common goldeneye	3.0
Unidentified duck	0.2	Bonaparte's gull	2.9
Common loon	0.2	Black duck	2.4
Great blue heron	0.1	Common merganser	1.3
Gadwall	0.1	Bufflehead	1.2
Unidentified merganser	0.1	Common tern	1.0
American wigeon	0.1		

[a]May-August: 92% unidentified scaup, 6% lesser scaup, 2% greater scaup.
[b]September-December: 34% unidentified scaup, 45% lesser scaup, 21% greater scaup.

Table 59. Comparison Between Lakes in the Relation Between Beaching Rate and Live Waterbird Numbers (LWC), Using 1980 Averages.

Lake	(a) No. beached waterbirds per km	(b) Mean no. LWC per km	Ratio[a]	"Species" ratios Ring-bld. gull	Herring gull	Water-fowl
Superior	.20	22.0	9.1	3.5	13.7	3.5
Michigan	.34	44.0	7.7	21.1	3.7	20.1
Huron	.23	93.4	2.5	1.4	2.6	2.7
Erie	.45	367.1	1.2	1.0	4.3	1.3
Ontario	.66	239.1	2.8	1.8	8.7	3.2

[a]Ratio = $\frac{a}{b} \times 10^3$

a fatal parasite of oldsquaw) could be higher. A participant at Michigan City, Indiana, commented that, in her locality, fishermen regularly remove drowned gulls from their nets. The lower lakes, which are similar in their use by waterbirds, provide an interesting comparison in that the ratios for ring-billed gulls, herring gulls and waterfowl are each about twice as high on Lake Ontario as on Lake Erie. Possibly the greater contamination of Lake Ontario by toxic chemicals increases mortality directly or indirectly.

The Detroit River was excluded from this comparison on the basis that it represents an atypical situation for the beaching of birds. Perhaps because of its current, very few birds were found at Detroit River routes.

Figure 35 compares the seasonal trends of both beached bird numbers and live waterbird numbers. Again, there is a rough correspondence. The graphs for herring gull and waterfowl suggest that there may be a lag time between peaks in live waterbird numbers and beached bird numbers. A lag time would be expected due to the delay between the time that a bird dies and is finally found on a survey, as well as the fact that mortality may often involved sick or weak birds that have lagged behind after other birds have left the area.

The statistical relationships between live waterbird counts and beached bird counts were examined using a linear regression procedure. None of the results proved to be statistically significant regardless of how the data were grouped (Table 60). Studies of the mallard (Geis 1972) and herring gull (Drury and Smith 1968) have suggested either a weak (mallard) or <u>inverse</u> correlation (gull) between winter bird abundance and mortality. Drury suggested that the inexperience of immature gulls resulted in their wandering from the high-density "choice" wintering areas (urban sites), with high mortality resulting in low density regions.

<u>Winter Periods, 1979-80 and 1980-81</u>. During the period January to April 1980, results of at least one survey were received for 72 survey routes. Ten of these had live waterbird count results only, 10 had beached bird results only, and 52 had both. In December 1979, when the live waterbird count procedure was first introduced, they were done at 20 routes.

In the period December 1980 to April 1981, results were received for 60 routes. Nine of these had beached bird results only, three had LWC results only, and 48 had both. In addition, participants made special counts at three areas affected by thermal discharges and one harbor. The number of participants sending results for the January-April 1980 period was unexpectedly low: there are results for only 52 survey routes. Of these, eight have beached bird survey results only.

The distribution of routes in both years is shown in Figure 36. In any month, live waterbird counts were done at a minimum of 27 and maximum of 51 routes and beached bird surveys were done at from 17 routes (in February 1980 when most beaches were iced-in) to 59 routes. The following discussion concentrates on the months January to April, the months of significant ice cover.

Table 60. Regression Analysis Results Comparing Live Waterbird Counts[a] (LC) and Beached Birds[b] Per km.

Groups	Comparison	N	r value	P level
Ungrouped	BG vs. LC	289	0.013	0.86
	BW vs. LC	289	-0.033	0.57
Lakes	BG vs. LC	5	0.553	0.33
	BW vs. LC	5	0.217	0.73
Regions[c]	BG vs. LC	14	0.098	0.74
	BW vs. LC	14	-0.113	0.70

[a]Mean values used when more than one count was taken on a survey.
[b]Beached gulls = BG; beached waterfowl = BW.
[c]Excluding Detroit River and St. Clair River.

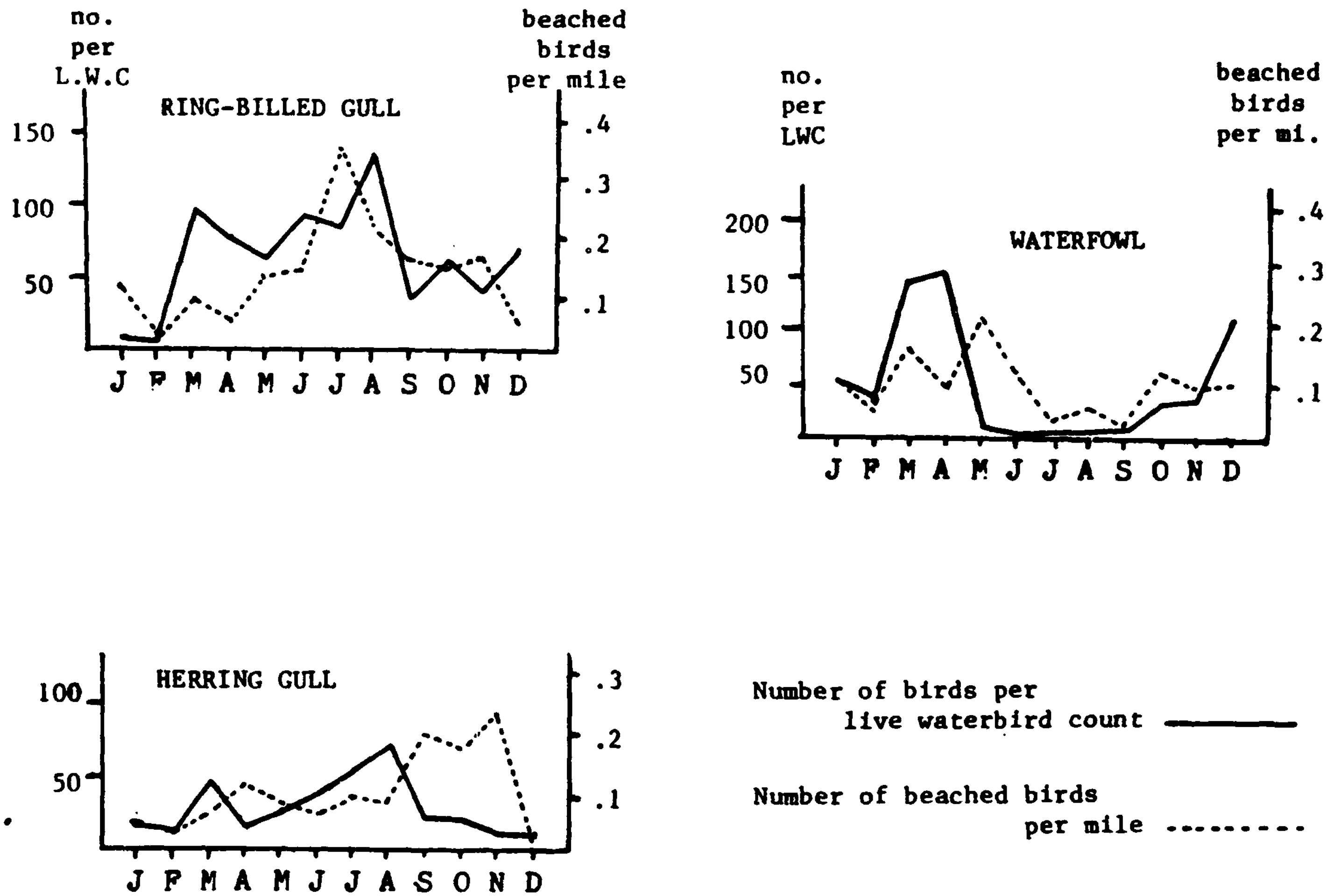


Figure 35. Seasonal patterns of live waterbird numbers and beached bird numbers in 1980.

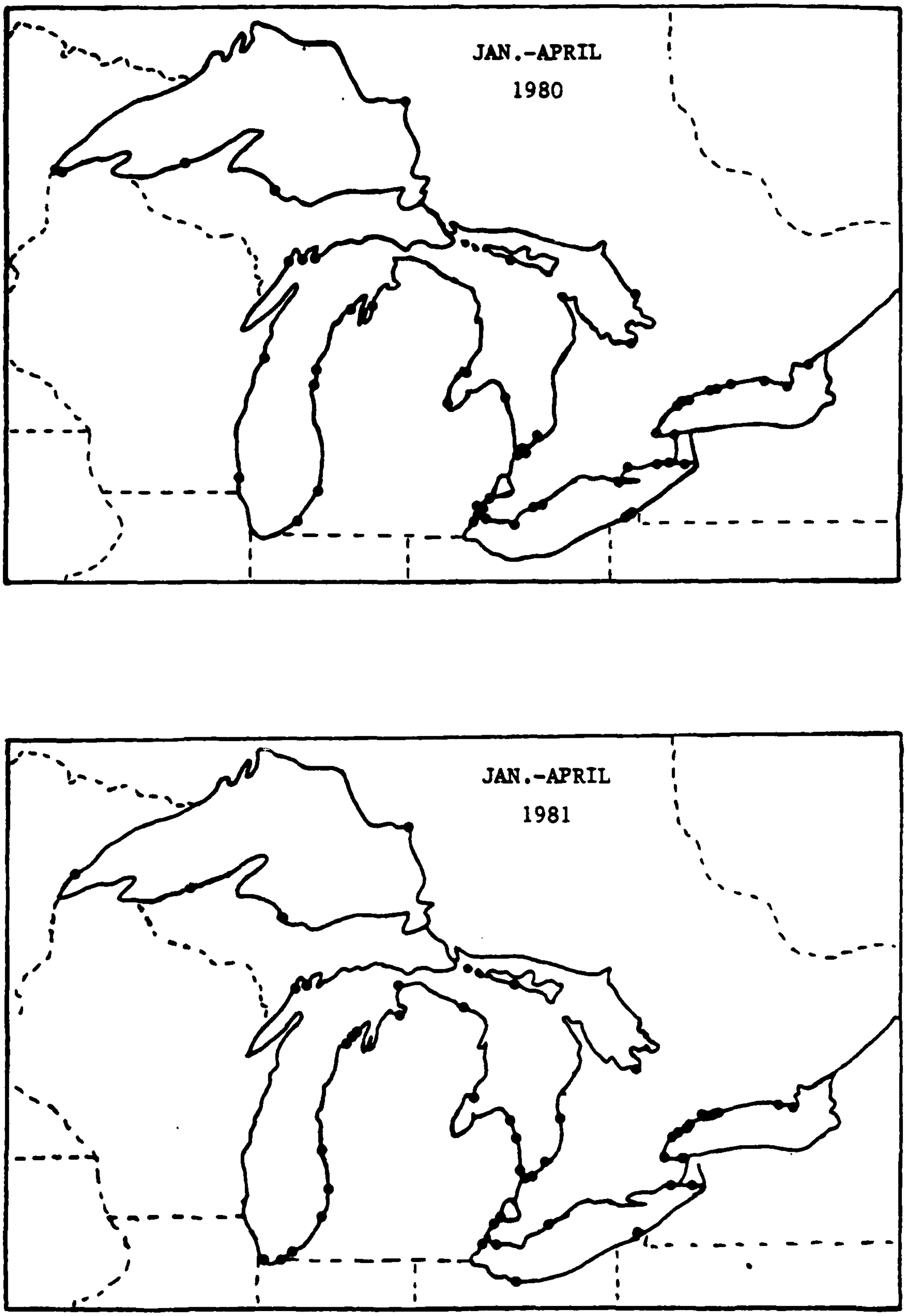


Figure 36. Distribution of survey routes on the Great Lakes in the periods Jan.-April 1980 and Jan.-April 1981.

Ice conditions

Mild temperatures in the winter of 1979-80 (which will be referred to as winter 1980) resulted in less than usual amounts of ice on lakes. The lakes did not freeze over except for the northern parts of Lake Michigan and Huron, and Saginaw Bay. Extensive ice formed mainly in bays and protected areas and where wind conditions caused windrowed pack ice to accumulate. In other years, Lake Michigan has had ice covering up to 80% of its surface, Lake Huron is normally 60% ice-covered and is 80% ice-covered in severe winters; Lake St. Clair freezes over completely, Lake Erie develops the most extensive ice-cover of the lakes and can be 95-100% ice covered in severe winters; and Lake Ontario develops an ice-cover in its eastern end that normally covers 15% of its surface and about 25% in severe winters (U. S. Army Corps of Engineers 1979).

In the following winter, ice conditions were generally more advanced in January and the first half of February, and then declined rapidly with the warm period in the last half of February. In March, less shoreline ice was reported than in the previous year.

Live waterbird counts

There was a clear difference between numbers of birds on the lower lakes and on the upper lakes. All species of gulls, herring gulls to a lesser extent, were much more numerous on Lakes Ontario and Erie than on the upper lakes. Ring-billed gulls were also numerous at the Detroit River routes. More large flocks were observed on the lower lakes, and gulls were present at 100% of the routes at some time in the four month period, whereas they were more often absent from routes on the upper lakes.

Ducks were also more numerous on the lower lakes and the Detroit River, especially mallards. Redhead, canvasback, and lesser scaup were found in their largest numbers on the Detroit River. Canada goose, greater scaup, bufflehead, and especially oldsquaw were found predominantly on Lake Ontario. Red-breasted mergansers were found in large numbers only on Lake Erie, and some species were found predominantly on the latter two lakes (black duck, and common merganser). Figure 37 illustrates the difference between lakes in the numbers of gulls and ducks seen on counts.

Due to the small size of the sample of survey routes, much of the variability inherent in and among individual routes is also present in mean values (for lake and month, etc.). Particularly in migration periods, counts of large flocks have a great effect on mean values. Therefore, interpretations of the data should be made carefully with respect to individual species. Table 63 shows the mean number per count for various species for Jan-Feb and March-April, 1980 and 1981. The distinct differences between years indicate this variability in the count data. Some of the difference also arises because there were fewer routes in 1981 on Lakes Erie and Huron and the Detroit River. Because the proportion of routes on different lakes changed and there are large between-lake differences, mean values for all lakes are not comparable between the two years.

Table 61. Most Numerous Species of Live Waterbird Counts from January to April.

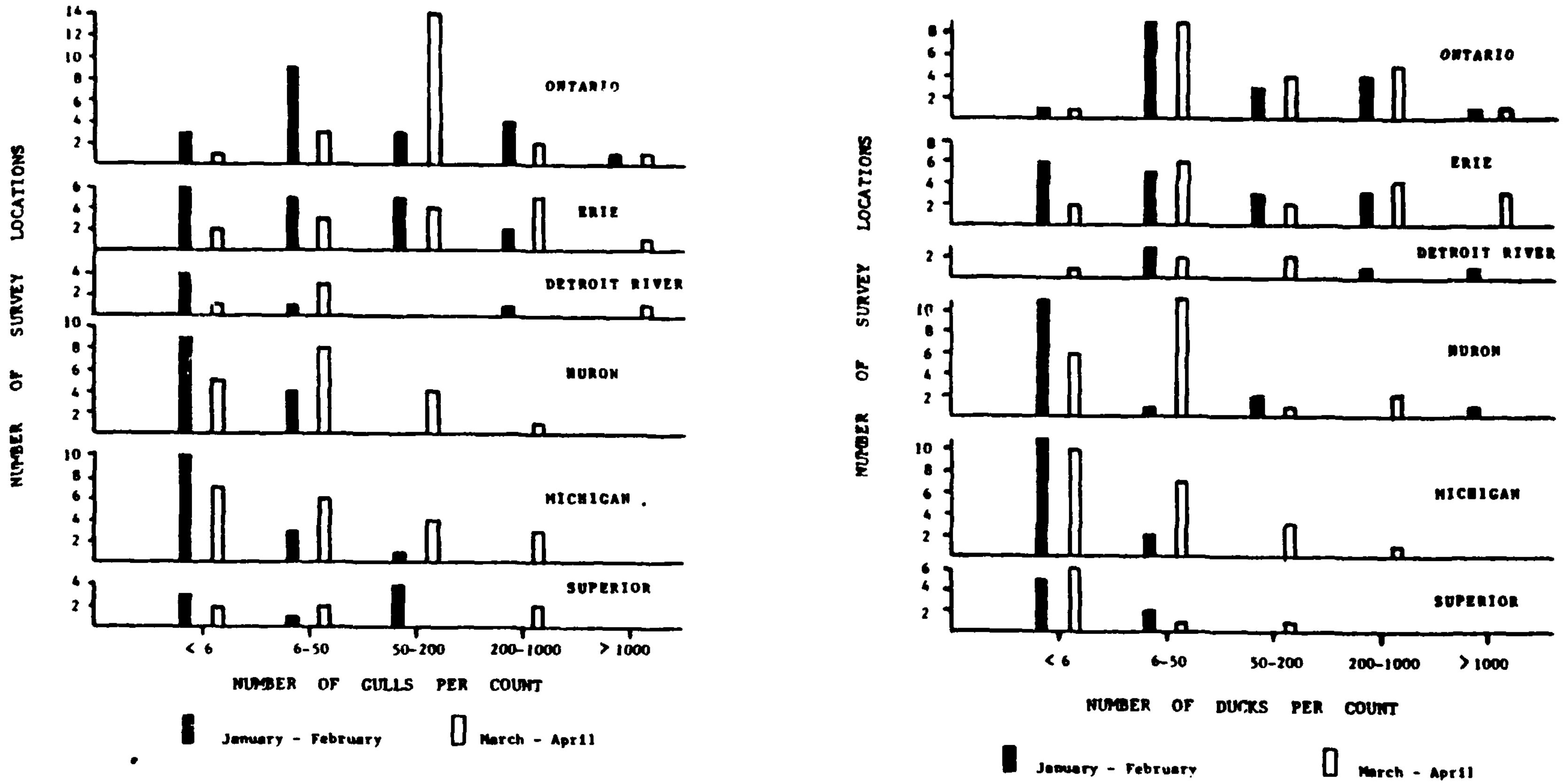
January - February 1980			January - February 1981		
Species	Mean no. per LWC	Mean no. per km	Species	Mean no. per LWC	Mean no. per km
Unidentified duck	76.0	47.1	Unidentified gull	38.4	23.8
Redhead	46.8	29.0	Oldsquaw	10.1	6.3
Canvasback	42.6	26.4	Black duck	9.3	5.8
Herring gull	18.1	11.2	Unidentified duck	8.8	5.5
Ring-billed gull	15.0	9.3	Herring gull	7.2	4.5
Oldsquaw	13.6	78.4	Ring-billed gull	7.0	4.3
Canada goose	12.5	7.8	Mallard	6.7	4.2
Mallard	12.2	7.6	Canada goose	6.4	4.0
Common goldeneye	8.7	5.4	Common merganser	3.5	2.2
Common merganser	7.9	4.9	Scaup spp. (8,18,74)[a]	1.7	1.1
Scaup spp. (41,5,54)[a]	7.9	4.9	Common goldeneye	1.7	1.1
Unidentified gull	3.6	2.2	Bufflehead	0.9	0.6
Black duck	2.8	1.7	Canvasback	0.3	0.2
Bufflehead	1.7	1.1	Gt. black-backed gull	0.3	0.2
Red-breasted merganser	1.6	1.0	Red-breasted merganser	0.2	0.1
Great black-backed gull	1.0	0.6	Redhead	0.1	0.1
All gulls[b]	36.7	22.7	All gulls[b]	52.6	32.6
All ducks	224.5	139.2	All ducks	45.9	28.5

March - April 1980			March - April 1981		
Ring-billed gull	85.6	53.1	Unidentified gull	87.1	54.0
Red-breasted merganser	59.9	37.1	Herring gull	21.5	13.3
Herring gull	31.5	19.5	Ring-billed gull	21.2	13.1
Bonaparte's gull	21.7	13.4	Unidentified duck	10.8	6.7
Unidentified gull	9.6	6.0	Red-breasted merganser	6.4	4.0
Canada goose	9.5	5.9	Canada goose	6.0	3.7
Scaup spp. (14,22,64)[a]	7.6	4.7	Bonaparte's gull	4.0	2.5
Mallard	6.3	3.9	Scaup spp. (9,2,71)[a]	3.4	2.1
Unidentified duck	5.7	3.5	Oldsquaw	2.0	1.2
Common goldeneye	5.6	3.5	Mallard	2.0	1.2
Common merganser	4.6	2.9	Bufflehead	0.8	0.5
Black duck	4.2	2.6	Redhead	0.2	0.1
Oldsquaw	2.0	1.2	Gt. black-backed gull	0.1	0.1
Bufflehead	1.9	1.2			
Canvasback	1.3	0.8			
Redhead	1.2	0.7			
Great black-backed gull	1.0	0.6			

Table 61 (concluded).

January - February 1980			January - February 1981		
Species	Mean no. per LWC	Mean no. per km	Species	Mean no. per LWC	Mean no. per km
All gulls[b]	126.7	78.6	All gulls[b]	129.8	80.4
All ducks	152.3	94.4	All ducks	34.8	21.6

[a]Numbers in parentheses are percentages of greater scaup, lesser scaup, and unidentified scaup, respectively.
[b]Ring-billed gulls plus herring gulls plus unidentified gulls.



(a) (b)

Figure 37. Frequency of survey locations with different levels of (a) gull numbers or (b) duck numbers in live waterbird counts in winter, shown by lake. Data for years 1980 and 1981 are summed. For each survey location, the count with the highest number was used for each of the Jan.-Feb. and March-April periods.

However, a rough comparison between years can be made looking at mean values for each lake. The following are generalizations of 1981 results compared with 1980 results. Common goldeneye, bufflehead, and redhead were apparently fewer in number. White-winged scoters decreased from small numbers on Lakes Erie and Ontario in winter 1980 to nil in 1981. Oldsquaw, found predominantly on Lake Ontario, were fewer at survey routes in January, and winter numbers were particularly smaller in the Oshawa-Whitby area. There were fewer scaup with the exception of Lake Ontario in January when there were more. Mallards and black ducks were higher in number on Lake Ontario and distinctly lower on Lake Erie. Throughout the lakes, fewer large flocks of common mergansers were reported, although smaller overall numbers were not necessarily indicated. Canada geese were fewer on the upper lakes. Mean numbers of ring-billed and herring gulls were smaller, but there were more unidentified gulls; all gulls combined were roughly equal in the two years on all lakes except Lake Michigan.

As mentioned in an earlier section, mean LWC values for species (Table 61) reflect the uneven distribution of survey routes. This is particularly true for 1980. Redheads and canvasbacks were most abundant in the winter period, but their numbers were concentrated on the Detroit River, and other waterfowl species were actually more numerous on the Great Lakes. In 1981, results were not received from these locations on the Detroit River, and consequently, redheads and canvasbacks were few in number. Canada geese and oldsquaw were found mostly on Lake Ontario, which has the highest density of survey routes. Red-breasted mergansers, which were the most abundant duck in March-April, were concentrated on a few routes on Lake Erie. In 1981, a large concentration of black ducks at two survey routes in the Whitby area on Lake Ontario gave this species a high average number per count in the Jan.-Feb. period.

The presence of shoreline ice, up to a few hundred meters, did not have an apparent effect on the presence of waterbirds. Patches of open water within large expanses of ice seemed well-used by gulls and ducks, but this may have been a concentrating effect. Not surprisingly, a complete ice cover at survey routes accompanied a great reduction in the number of waterbirds observed (Tables 62 and 63).

It appears that ice conditions were not primarily responsible for the regional differences in waterbird numbers. Differences in the ranges and migration routes of some species are involved. Differences in food supply may be the most important factor. Data are lacking on this, but an improved food supply probably results in the preferential use of sites with warm water outflows, as discussed in the next section. Also, there may be higher use of inland waterways by birds in some regions. A participant on eastern Lake Michigan commented that few birds were present at his survey route, but many frequented inland lakes, including Lake Mactawa and Spring Lake where he has seen flocks of over a thousand gulls.

The uneven, non-random distribution of survey routes may also affect the comparison between lakes. On Lake Ontario, all but two survey routes involved in the Jan-Apr. 1981 survey period were in urban areas. On all other lakes the situation is the reverse, with most routes being rural. Gulls and some species of ducks concentrate in urban areas in winter. Lake Ontario (in

Table 62. Mean Number of Ducks Per km (and ducks per count) at Survey Routes With and Without Complete Ice Cover, using combined data for the February-March, period of 1980 and 1981.

Lake	February Routes with open water	February Routes with complete ice cover	March Routes with open water	March Routes with complete ice cover
	No. of ducks per km (no. survey routes)[a]			
Superior and Michigan	0.6(10.2)	0 (8.8)	2.5(15.5)	0 (5.5)
Huron	2.4(1.7)	0.1(7.2)	10.7(11.7)	1.9(3.2)
L. Erie/L. St. Clair/ and Detroit R.	290.8(18)	50.0(5)	88.5(20.1)	0.9(5.9)
	number of ducks per count			
Superior and Michigan	1.0	0	4.1	0
Huron	3.8	0.1	17.2	3.0
L. Erie/L. St. Clair/ and Detroit R.	469.1	80.6	304.1	1.5

[a]Number of survey routes, using for each the proportion of counts with and without complete ice cover.

Table 63. Mean Number of Gulls Per km (and gulls per count) at Survey Routes With and Without Complete Ice Cover, for February and March, 1980 and 1981.

Lake	February: Routes with open water	February: Routes with complete ice cover	March: Routes with open water	March: Routes with complete ice cover
	No. of gulls per km (no. survey routes)[a]			
Superior and Michigan	6.4(10.2)	6.0(8.8)	7.8(15.5)	8.0(5.5)
Huron	3.8(1.7)	1.2(7.2)	66.2(11.7)	2.5(3.2)
L. Erie/L. St. Clair/ and Detroit R.	29.6(18)	5.0(5)	164.4(20.1)	5.6(5.9)
	number of gulls per count			
Superior and Michigan	10.3	9.6	12.6	12.9
Huron	6.1	2.0	106.7	4.1
L. Erie/L. St. Clair/ and Detroit R.	47.7	8.0	265.2	9.1

[a]Number of survey routes, using for each the proportion of counts with and without complete ice cover.

Ontario, where all routes are located) has a higher proportion of urban shoreline than other lakes, but there is still a bias toward urban routes which probably means higher mean LWC values for some species. It is also worth mentioning that among Lake Huron survey routes is an atypical one of Kettle Point (northeast of Sarnia, Ont.) where exceptionally large flocks of gulls (herring, bonaparte's, and ring-billed) and ducks (particularly red-breasted mergansers, and many other species) in March and April probably had a disproportionately large effect on mean LWC values for the lake.

In newsletters to GLBBS participants, a request was made for any information on birds using shipping lanes in ice-bound areas. Only one participant responded to this. A. Weir reported on the use by birds of shipping lanes on the Detroit River between Belle Isle and the Canadian mainland. The shipping lanes were apparently open continuously through the winter in this iced-in area, and were used by small numbers of ducks, particularly common goldeneye and bufflehead, and gulls were often seen "riding the ice floes down the river". Other parts of the river had unconsolidated floe ice or brash and there were areas of open water, including the channel between Belle Isle and Detroit, where large rafts of ducks (canvasback and redhead) were noted by another participant. Generally the Detroit River becomes ice-covered in parts of its lower half and on both sides of Belle Isle (U. S. Army Corps of Engineers 1979). In the 1980-81 winter, the river was reported to be frozen over by 26 December at the Belle Isle survey route, at which time 167 ducks (including 97 common goldeneye) were using the open areas created by the Coast Guard Ice Breakers. Open water and moderate numbers of ducks were reported there through the remainder of the winter.

In several harbors on Lake Michigan (Benton Harbor, Burns Waterway, and Calumet Harbor) periodic barge traffic in mid-winter creates open water areas that generally freeze over between usages. When Benton Harbor was visited on 27 February 1980, 120 mallards (that had arrived since an oil barge had broken ice in the harbor in the previous week) were present. Calumet Harbor had very little open water and no birds when visited, but a harbor employee had seen ducks a few days earlier when there had been more open water. Overwintering ducks on Lake Michigan apparently wander extensively, as discussed in the next section, and so would be expected to avail themselves of temporary open water in harbors.

Special Counts at Harbors/Power Plants. Large concentrations of waterfowl were found at only three thermal discharge locations visited (Table 64): Nanticoke TGS (thermal generating station) on Lake Erie (1065 ducks), Monroe TGS on Lake Erie (1723 ducks), and Karn-Weadock TGS on Lake Huron (5517 and 7594 ducks on separate counts). Common mergansers, mallards and black ducks made up the majority, and scaup were also numerous at Nanticoke.

The first two locations were known to be overwintering areas for large numbers of waterfowl. Between 6000 and 800 mallards and black ducks were reported to have used the ice-free area at Monroe TSG in 1971 (Reed 1971). Surveys of the Nanticoke TGS ice hole in the winters of 1978 and 1979 determined that approximately 2500 waterfowl, mostly mergansers, used the thermal plume on a regular basis (Wianko 1979). Concentrations of waterfowl have also been found on Lake Ontario at these Ontario Hydro-electric plants: Lakeview, Hearn, Pickering, and Lennox (now closed). At Pickering NGS (nuclear generating station), waterfowl numbers peaked at over 3000 in late December

Table 64. Locations of Power Plants and Harbor Sites for Special Waterbird Counts.

Area	Location	Site: Power plant	Site: Harbor
Western shore, Lake Michigan	Port Washington	x	
	Milwaukee		x
	Oak Creek	x	
	Racine		x
	Kenosha		x
	Zion	x	
	Waukegan	x	x
	Chicago		x
	Chicago Intern. Port		x
South shore, Lake Michigan	Calumet		x
	Indiana Harbor[a]		x
	Burns Waterway		x
	Michigan City	x	x
	State Line	x	
	Mitchell	x	
	Bailley	x	
East shore, Lake Michigan	Cook	x	
	Benton Harbor		x
Lake Huron	Bruce A	x	
	Weadock	x	
St. Clair River	Marysville	x	
	St. Clair	x	
	Lambton	x	
Detroit River	Connors Creek	x	
	Rouge River	x	
Lake Erie	Monroe	x	
	Nanticoke	x	
Lake Ontario	Hearn	x	

[a]Thermal discharge (industrial sources).

and declined to about 1500 in January and February. They were mostly mallards, with up to several hundred black ducks, common mergansers, and scaup (Hester 1979). In the vicinity of the Toronto Harbor Eastern Headland (Leslie Spit) and Hearn TGS, numbers of waterfowl in the winter of 1975-76 peaked in December and varied roughly between 500 and 2000 in January and February. Oldsquaw, common merganser, greater scaup, gadwall and bufflehead were present in the largest numbers (Freedman and McKay 1977). The same species were present in smaller numbers, probably due to the milder conditions.

About 200 ducks, mostly common mergansers, and 400-500 herring gulls were found at the Bruce NGS on Lake Huron. This represents an isolated concentration of birds in a part of the lake in which fluctuating shoreline ice often accumulates to a width of several hundred meters.

Despite the lack of ice cover in the winter of 1979-80, birds still concentrated at plants such as Nanticoke and Hearn. Warm water evidently attracts birds to the plant sites, either by attracting them directly or by improving the local food supply on at least a short-term basis (e.g., fish are entrained to warm water generating sites). At Nanticoke TGS and Pickering NGS, common mergansers were reported to feed frequently in the immediate vicinity of the discharge channels and other diving ducks were attracted to the area further offshore to feed, suggesting that the plant's 'thermal plume' offered a good food supply of fish and/or invertebrates. A recent increase in the numbers of common mergansers overwintering in the vicinity of Hearn TGS is attributed to an abundance of local benthic invertebrates and high fish populations arising from the effects of the thermal outflow. In addition, some species of aquatic vegetation are abundant and may be among the food items of wintering gadwall (Freedman and McKay 1977). At Pickering NGS and Monroe TGS, mallards and other surface-feeding ducks used the thermal plumes as loafing and overnight resting areas and fed inland during the day (Hester 1979, Reed 1971). The Monroe thermal plume provided an open water area in an otherwise frozen lake, while Pickering attracted these ducks because of the shelter afforded by the plant's intake groynes. A combination of factors presumably attracts birds to power plants in urban areas such as Toronto's Hearn TGS, including open water, shelter from wind and waves, and a food supply enriched by a warm water outflow and municipal waste.

Few birds or none were found at power plants on the Detroit and St. Clair Rivers. There was almost no ice in view on the rivers and there was an absence of shelter from the strong river currents, which act to dissipate the thermal discharge entering the river. Dense concentrations of fish (mostly gizzard shad, Dorosoma cepedianum) were found in the discharge channels of two plants, and a GLBBS participant (H. R. Holland) from Sarnia, Ontario, reported that warm water outflows from petrochemical plants and the Lambton TGS are well-used by birds. Several thousand ducks winter along the St. Clair River - canvasbacks, redheads, mallards, scaup, common goldeneye, buffleheads, mergansers, and Canada geese. On Lake Huron, winds can either remove most pack ice from the shore or build it up to the extent that there is no open water in sight. Birds feed on the open water in the lake when it is present and on the river when it is not.

No large concentrations of birds were found at Lake Michigan power plants, but moderate numbers of ducks and gulls were present at most in February 1980.

There was an average of 60 ducks and 74 gulls, compared with only 0.8 ducks per count and 8.7 gulls per count at Lake Michigan survey routes in February 1980 (Table 67). By contrast, 1981 visits to four Lake Michigan power plants found very few birds, actually fewer ducks and gulls on average than at survey routes (see Table 68). The weather was exceptionally cold on the February 1980 field trip (15-25° F, on average) and exceptionally warm on the February 1981 field trip (daytime temperatures 40-60° F). Herring gulls comprised all the gulls identified to species in 1980 and almost all in 1981, and the common ducks, in decreasing order of abundance, were mallard, scaup (few in 1980, many in 1981), oldsquaw, common goldeneye, common merganser, and bufflehead. Most plants on the south and southeastern shores of the lake afforded open water areas inside 100 m or more of solid pack ice at the shoreline. There was little ice along the west shore of the lake (although offshore floe ice was visible) on the days visited. Two power plants were located in protected harbors, and Oak Creek TGS had an area of protected water in its coal barge slip. A GLBBS participant (T. Wittbrot) had a survey route at the Oak Creek plant, and he describes the normal situation as follows: waterfowl numbers and diversity increase around mid-January and decrease in late February or early March. On many days, the following birds may be present at once: 200-300 mallards, several hundred scaup, dozens or hundreds of herring gulls, one or two dozen black ducks, several oldsquaw, Canada geese and bufflehead, and perhaps a ring-billed gull or pintail. On other days there may be no birds. On cold days, birds are seen in rafts a few hundred meters offshore, while dabbling ducks use shallower areas, and gulls are sometimes seen "fishing" in the discharge areas. Thus, high mobility is a distinct feature of overwintering waterfowl on Lake Michigan. Several harbor and power plant employees commented that ducks were present on some days and absent on others. While at Oak Creek TGS, I observed 200 mallards appear from out of view flying along the shoreline and then settling on the water at the plant site in or near the coal barge slip. The mobility is presumably due to the presence of extensive open water on the lake (at least in the two winters of the study) and the movement of large amounts of pack ice to different parts of the shoreline depending on wind direction.

Many of the thermal discharge sites visited had high concentrations of fish. People were fishing at most of them, and reported good fishing. Species mentioned were brook trout, lake trout (*Salvelinus fontinalis*, *S. namaycush*), brown trout, rainbow trout (*Salmo trutta*, *S. gairdneri*), coho salmon (*Oncorhynchus kisutch*), yellow perch (*Perca flavescens*), and bass (*Micropterus* sp.). By contrast, no one was fishing at the harbors without thermal outflows. At two of the sites (Waukegan Harbor and Chicago Harbor) grain was being put out for wintering ducks.

In February of both years, Lake Michigan harbors had many more ducks and gulls than GLBBS survey routes on the lake, with an average of 121 ducks and 32 gulls. Indiana Harbor and Port Washington harbor also had significant thermal discharges, and the numbers of gulls and ducks there were similar to those of harbors. Most harbors visited had substantial open water areas, the last two because of thermal discharges, some because of periodic shipping (Benton Harbor, Burns Waterway, Calumet Harbor), and others for apparently natural reasons (Kenosha and Racine).

In March 1981, Lake Michigan harbors were found on average to have more than twenty times the number of ducks and gulls than survey routes (Table 67).

Table 65. Mean Numbers of Live Waterbirds[a] at Harbors and Thermal Discharge Sites in Jan-Feb 1980 Compared with Survey Route Means.

	Lake Michigan				L. Superior		Lake Erie			Lake Huron			Lake Ontario		
Species	Survey routes	Har-bors[b]	Therm. disch. sites[b]		Survey routes		Survey routes	Monroe TGS	Nanti-coke TGS	Survey routes		BruceA NGS	Survey routes	Hearn TGS	
N =	6	8	5	2	5	1	9	1	1	7	1	1	9	1	1
Mallard		37.6	43.0				27.2	34	213		405	4	7.2		
Black duck		0.8					8.4	50	10		270		4.5		12
Redhead							5.6	10	11				2.1	4	
Scaup spp.		0.1	0.4	2.0			2.6	30	321		5		30.0	8	8
C. Goldeneye	0.7	10.0	3.0	8.5			5.5		10	0.3	1	4	10.7	8	2
Bufflehead	0.1	1.5					0.03					46	5.0	6	2
Oldsquaw		10.6	0.2	19.0									30.2	5	
C. merganser		2.8	12.2				15.0	65	300	0.7	1930	185	3.3	10	63
Unid. merganser			0.4		0.1		0.1	200		0.1	2985				
Unid. duck		7.1			0.3		1.6	1334	200		1995	2	8.7	60	
Other ducks			0.4	1.0			3.1	1	3		3		3.2	4	

Table 65 (concluded).

All ducks	0.8	70.3	59.6	30.5	0.4		69.0	1724	1068	1.1	7594	137	104.9	105	87
Herring gull		13.8	72.0	2.5	0.2	145	57.1	36	48	1.6		473	19.1	13	195
Ring-bld gull		0.2					5.6		1				31.7		17
Unid. gull	8.7	2.4	2.0	125.0	0.1		0.2	250	76	0.2			16.5	75	
All gulls	8.7	33.5	74.0	127.5	0.3	145	62.9	286	125	1.8		473	67.3	88	212

[a]At power plants, the count taken at the lake was summed with counts at discharge and intake channels.
[b]Excluding Port Washington and Indiana Harbor.

Table 66. Mean Numbers of Live Waterbirds[a] at Harbors and Thermal Discharge Sites in Jan-Feb 1981 Compared with Survey Route Means.

Species	FEBRUARY				JANUARY AND FEBRUARY							
	Lake Michigan				Lake Huron		Lake Superior		Detroit River		Lake Ontario	
	Survey routes	Harbors[b]	Therm. disch. sites[b]	Indiana Harbor	Survey routes	Harbor Beach harbor	Survey routes	Presque Isle TGS	Belle Isle survey route	Connor's Ck. TGS	other survey routes	near Pickering TGS
N =	5	10	5	1	2	1	4	1	1	1	9	1
Mallard	3.0	71.5	5.2						29.7	239.8	24.6	.
Black duck		0.5	0.8						4.6	16.5	27.7	.
Scaup spp.		49.8		75			1.0			4.3	2.6	27.0
C. Goldeneye		12.9	0.2			2.0		4.0	1.8	67.3	2.5	33.0
Bufflehead		2.0					1.5			1.8	2.1	5.0
Oldsquaw		17.8									29.0	.
C. merganser		5.5		2						20.3	0.7	5.0
Unid. merganser		0.1	0.2		0.6						0.1	.
Unid. duck		0.6								125.0	23.1	.
Other ducks	0.6	0.2		8					0.5	11.0	13.1	2.0
All ducks	3.6	162.0	6.4	85	0.6	2.0	2.5	4.0	36.6	486.0	125.5	42.0
Herring gull	0	28.1	2.2	7	1.6	68.0	0.2	2.0	1.3	0.8	11.3	

Table 66 (concluded).

Ring-bld. gull		0.1	0.4									15.5	
Unid. gull	1.1	2.6					14.7					2.2	912.5
All gulls	1.1	30.8	2.6	7	1.6	68.0	14.9	2.0	1.3		0.8	29.0	912.5

[a]At power plants, the count taken at the lake was summed with counts at discharge and intake channels.
[b]Excluding Indiana Harbor.

Table 67. Mean Numbers of Live Waterbirds[a] at Harbors and Thermal Discharge Sites in March 1981 Compared with Survey Route Means.

	Lake Michigan				Lake Huron		Lake Superior		Detroit River		Lake Erie	
Species	Survey routes	Harbors[b]	Therm. disch. sites[b]	Indiana Harbor	Survey routes	Harbor Beach harbor	Survey routes	Presque Isle TGS	Belle Isle survey route	Connor's Ck. TGS	other survey routes	Nanticoke TGS
N =	6	10	5	1	6	1	3	1	1	1	4	1
Herring gull	2.4	17.9	24.8	3	31.1	18	16.4	7	1.0		80.3	11
Ring-billed gull	0.3	21.0	6.0		49.0		0		7.4	4	293.3	42
Unid. gull	0	52.0			7.5		2.8		0		71.6	40
All gulls	2.7	90.9	30.8	3	87.6	18	19.2	7	8.4	4	445.2	93
All ducks	4.7	101.0	0.8	110	21.3	3	2.6		22.1	60	72.2	56

[a] At power plants, the count taken at the lake was summed with counts at discharge and intake channels.
[b] Excluding Indiana Harbor.

At thermal discharge sites (not including Indiana Harbor), gull numbers were also relatively high, but there were fewer ducks on average than at survey routes. Ice had gone from the shoreline at the power plants, leaving open exposed shoreline. Nanticoke TGS on Lake Erie had fewer than the high average numbers of ducks and gulls at Lake Erie survey routes.

Of special note is the finding of live oil-coated ducks at Indiana Harbor during visits to Inland Steel Company's plant in February and March 1981. On 18 February, there were nine scaup at the south corner of the harbor, and six of them were covered with a dark substance believed to be oil. The ducks exhibited no abnormal behavior. Small amounts of light oil are contained in Inland Steel's discharge effluent. On 26 March, a group of 105 scaup were at the mouth of the Indiana Harbor Canal (in the harbor). At least four males were oiled, with white feathers discolored light brown. It was impossible to tell if female scaup were oiled, due to their brown plumage. Inland Steel Air and Water Quality Control officer Tom Barnett commented that earlier that day there was an accidental oil spill from the Youngstown Steel and Tube Company on the other side of Indiana Harbor Canal. Inland Steel was involved in cleaning up the oil that had been blown across the harbor and deposited at their plant site. Furthermore, oil periodically comes down the canal and into the harbor from any of a number of plants situated on the canal. Mr. Barnett also commented that many more ducks use Indiana Harbor in fall than in spring or winter, with several thousand ducks present, particularly scaup.

A survey at Frenchman's Bay on Lake Ontario east of Toronto is within a mile of the large Pickering nuclear generating station. Large counts of gulls were made there in January and February 1981, 1000 and 825 gulls respectively. Small or moderate numbers of ducks were recorded, while as mentioned, large numbers of ducks (about 1500) overwinter at the Pickering plant site itself.

A participant with a survey route at Presque Isle, Pennsylvania, reports that thermal discharges at the Erie Public Dock (2 miles west of his survey route) and Hammermill Paper Company (2 miles east of the survey route) create open water areas throughout the winter which often hold several thousand waterfowl and gulls, especially at the Public Dock. No further details were given.

Summary

Live waterbird counts done in January and February 1980 and 1981 at survey routes around the Great Lakes recorded the presence of many species of waterbirds, including the following, in decreasing order of importance: herring gulls, ring-billed gull, oldsquaw, mallard, Canada goose, common merganser, common goldeneye, greater scaup, black duck, and bufflehead. In addition, up to 7500 redhead and 5500 canvasback were reported at a survey route on the Detroit River in February 1980.

Both ducks and gulls were much more numerous at survey routes on lakes Ontario and Erie and the Detroit River than on the upper lakes. This was mainly an effect of larger flock size, particularly for gulls. Herring gulls were more widely distributed than ring-billed gulls which were concentrated on the lower lakes and Detroit River.

In the winter of 1979-80, none of the Great Lakes froze over except for the northern parts of Lakes Michigan and Huron, and Saginaw Bay. Extensive ice formed in some bays and protected areas, but there was open water within view of most survey routes throughout the lakes. In the following winter, ice conditions were more advanced in January and early February, with substantially more ice cover on Lakes Erie and Huron. Mallards and black ducks at survey routes were higher in number on Lake Ontario than in the previous year and distinctly lower on Lake Erie. In late February there was a period of very warm weather, and less shoreline ice was reported at survey routes in March than in the previous March.

The presence of shoreline ice, up to a few hundred meters, did not have an apparent effect on the presence of waterbirds. However, a complete ice cover greatly reduced the number of birds seen on counts.

Only one report was received of birds using shipping lanes. This was of small numbers of ducks using a shipping lane through one of the frozen sections of the Detroit River. This has little significance in view of the large numbers of ducks found in nearby unfrozen parts of the river without shipping activity (see DETROIT RIVER, GROUND COUNTS).

Harbors, which provide shelter and often open water, are used preferentially by birds during the winter. In some Lake Michigan harbors, shipping activity periodically creates open water which refreezes quickly. Wintering ducks on this lake are highly transient, probably due to shifting shoreline ice, and use these harbors when they are open.

Numbers of ducks and gulls present at sites of thermal discharge on Lake Michigan in February 1980 were similar to numbers at harbors (an average of 74 gulls and 60 ducks) but were much lower in February 1981 (an average of six ducks and three gulls). The difference may have been related to weather. The February 1980 censuses were made in an exceptionally cold period in an otherwise warm winter, while the February 1981 censuses were made in an exceptionally warm period following a very cold December and January.

Elsewhere, some large concentrations of birds were found at thermal discharge sites. Between 1000 and 7600 ducks were seen at each of three power plants, located in Saginaw Bay (Lake Huron), western Lake Erie, and northeastern Lake Erie. Common mergansers, mallards, and black ducks made up the majority. Several hundred ducks also overwintered in the vicinity of power plants on northeastern Lake Huron and at Toronto, and other Lake Ontario power plants are known to support concentrations of waterfowl through the winter. Few birds were seen in the vicinity of power plants on the Detroit and St. Clair Rivers, none of which had areas sheltered from the fast river currents. Exceptional mid-winter concentrations of herring gulls were found in February at two power plants on Lake Superior and northern Lake Huron (145 and 473 birds, respectively). Notable numbers of 800-1000 unidentified gulls were recorded through the winter at a survey route near a large nuclear power plant east of Toronto on Lake Ontario.

All areas in which wintering waterfowl concentrated provided open water and some degree of protection from winds and waves. At some Lake Michigan power plants, protection was afforded by extensive shoreline ice surrounding an ice hole created at the discharge area. 'Thermal plumes' from plants

discharging warm water provided an extra attraction for birds. This was evident because birds were attracted to these sites even in regions where the lake was largely ice-free. Data on the reasons for this are lacking. There might be a direct attraction to warmer water, and there is evidence that effect of temperature on the food supply may be important. Fish were abundant in the vicinity of Lake Michigan power plants and in discharge channels of two plants on the Detroit and St. Clair Rivers. The same has been reported for a Toronto power plant. The effect of thermal discharges is one of the reasons given for the increase in the numbers of wintering waterfowl in the Toronto region (Goodwin et al. 1977). There have been observations that common mergansers often feed in the vicinity of discharge channels at two other stations, on Lakes Erie and Ontario, and that other diving ducks feed preferentially in the area of the plants but further offshore. Thermal plumes seem to be particularly attractive to some species such as common mergansers, and less so to others, such as oldsquaw. In two cases it has been documented that thermal plumes are used in winter as overnight resting areas by large numbers of mallards and black ducks which feed inland during the day.

Concentrations of mallard, black ducks, and common mergansers at power plants on Lake Ontario, Lake Huron, and Lake Erie represent higher numbers overwintering than have been reported in the literature (e.g., Bellrose 1976). Numbers of these and perhaps other species overwintering have probably increased due to the operation of these plants. In addition, provision of food at urban areas such as Toronto entices further numbers of mallards and Canada geese to overwinter. Also, the number of redheads and canvasbacks found overwintering on the Detroit River in this study are also higher than previously reported.

In conclusion, in the winters of 1979-80 and 1980-81, there was widespread use of the lower Great Lakes by a number of waterbird species. Our data indicate that the waterbird distribution was affected significantly by the operation of plants producing thermal discharges, and minimally by shipping activity, at least in the areas of survey coverage.

Beached bird surveys were conducted at much the same set of survey routes as live waterbird counts. There was a geographic variation in the beaching rate that was not statistically correlated with live waterbird numbers. Beached bird surveys suggest that mortality in winter and early spring is not particularly high in relation to numbers of live birds present. Most importantly, no abnormally large numbers of beached birds was found at any survey route, including those with concentrations of overwintering waterbirds.

MAJOR BIRD MIGRATION ROUTES AND STAGING AREAS (STUDY UNIT 5)

Methods

The major migration routes and significant staging areas of bird species using the shorelines of the Upper Great Lakes were examined through a literature search and interviews with various resource persons. The literature search included a review of theses and other pertinent publications at libraries and governmental offices. Special emphasis was placed on inspection of published and unpublished documents in state and federal wildlife agency files and more obscure materials in lesser known journals.

Primary references were located using the bibliographies of major resource books dealing with the various bird groups, (e.g., Bellrose 1976 for waterfowl), previously compiled bibliographies and literature summaries pertaining to the Great Lakes (e.g., U. S. Dept. of Agriculture 1966, 1967, 1969a, 1969b, 1970, National Technical Information Service 1972a, 1972b, 1972c, Green et al. 1974, Great Lakes Basin Service 1979a, 1979b), and indices to technical journals. In addition, a BIOSIS library computer search of Biological Abstracts and Bioresearch Index was conducted.

Additional references and unpublished information were obtained through interviews with personnel from state and federal wildlife agencies, international and interstate commissions, and universities, as well as through contact with local birdwatchers. "Interviews" were made by letter, telephone, and/or personal contact. The information from these sources was used to compile a list of sites known to have significant migratory bird use.

Results

Major Migratory Use Areas. Information regarding migratory concentration sites for most species and family groups comes primarily from knowledge of birdwatchers from the various regions around the Great Lakes. With the exception of a few site-specific studies, this information is limited to arrival and departure dates and general statements about abundance. Although not quantitative, it is useful in locating the major usage areas. Most information has been presented in some form in state ornithological journals (The Loon, Minnesota, The Passenger Pigeon, Wisconsin; The Jack-Pine Warbler, Michigan) as well as in various state bird books.

In addition, one prior study, similar in scope and purpose to the present effort, was published as part of a document summarizing Great Lakes shoreline values and uses (Great Lakes Basin Commission 1975). The study included a list of areas considered "critical" migratory concentration sites. Resources used in this assessment were much the same as in the present work. The criteria used to determine "critical" were not clear, but it is assumed that the areas listed are considered major migration areas. The results of the present work represent a corroboration and expansion of the foregoing list, and are presented in Table 68. In most instances the major migratory bird use of the area is noted. Exceptional qualities or values of a given area, if known, are also given.

Migration Corridors. The Upper Great Lakes lie between two major migratory bird flyways, the Mississippi and the Atlantic, and as such, the actual corridors used by various species exhibit much overlap and present a complex pattern within this region. In the case of those species tending to follow coastlines, e.g., raptors and passerines, definite lanes of concentration and funneling points are evident, and strongly reflect the physical configuration of the lakes. In general, these species tend to concentrate along western and northern shores during fall movements and eastern and southern shores during spring. Due to the overall lack of comprehensive studies of migratory movements on a regional basis, delineation of corridors beyond this generalization is difficult. Thus, the foregoing list of known concentration areas is perhaps the most useful format for information regarding most bird groups.

While quantitative data on migratory movements are sparse for most birds, two groups, diurnal raptors and waterfowl, have received considerable study. Information regarding these groups is more abundant due to the special interest they hold and the fact that they are more visible components of migratory movements.

Because they avoid crossing large bodies of water, raptors concentrate along shorelines of the Great Lakes during migration. Discovery of this phenomonon has led to the development of a number of "hawk lookouts" throughout the Great Lakes region. In recent years, several groups, including the U. S. Fish and Wildlife Service and the Hawk Migration Association of North America (HMANA), have initiated efforts to standardize and coordinate documentation of migratory movements at these sites as well as throughout the United States. At present, most data are collected during the fall, although the spring migration is receiving increased attention. Due to the above developments, knowledge of major raptor migration lanes has increased dramatically in recent years. This information is available in seasonal summaries published by HMANA and in a text addressing autumn hawk flights (Heintzelman 1975). These species follow the general pattern already described for birds which follow the coastlines. Thus major concentrations exist at points such as Duluth, Minnesota, Detroit, Michigan, and the Straits of Mackinac. Again, known concentrations are noted in Table 68.

Waterfowl migratory movements have perhaps received more attention than those of any other avian group primarily due to their status as game species. Federal and state widlife agencies document migration movements of these species on an annual basis, although data are restricted primarily to designated wildlife refuge areas. Due to the acute interest by the general public, major staging areas are fairly well known for fall movements. The spring migration of waterfowl has not been documented as well. This is partially due to the fact that spring movements tend to be more dispersed geographically, but also reflects the emphasis on study of fall populations due to interest in hunting and post-breeding population levels. Previous summaries of major waterfowl migration sites in the Upper Great Lakes region have been published. Most useful in this regard are those concerning Great Lakes shoreline of the state of Michigan (Jaworski and Raphael 1978, Martz 1976). Several in-house publications also were found in state wildlife files.

Due to the wealth of information available pertaining to waterfowl migratory movements, it is the one bird group for which somewhat accurate

Table 68. Major Bird Migration Areas-Upper Great Lakes[a].

Area	Major bird use	Remarks
Carlton, St. Louis & Lake Counties, MN		
Duluth Bluffs	Hawk	
St. Louis River Bottomlands	Hawk, waterfowl	Migrating eagles feeding-resting point.
Minnesota Point	Herring gull, common tern, shorebird, passerines, hawk	
Iron, Ashland, Bayfield, & Douglad Counties, WI		
Allouez Bay	Waterfowl	Major diving duck concentrations.
Mouth of Brule	Waterfowl, shorebird, passerines	
Port Wing Slough	Waterfowl, shorebird, passerine	
Bark Bay Slough & Point	Waterfowl, shorebird, passerine	
Sand Point	Waterfowl, shorebird, passerine, hawk	
Point Detour	Waterfowl, shorebird, passerine, hawk	
Outer Island Slough	Waterfowl, passerine	
South Stockton Island	Waterfowl, passerine	
Stockton Island Slough	Waterfowl, passerine	
Michigan Island Slough (southwest portion)	Waterfowl, passerine	
Kakagon Sloughs & Oak Point	Waterfowl, shorebird, woodcock, passerine, hawk	One of the finest marsh habitats along Lake Superior.

Table 68 (continued).

Area	Major bird use	Remarks
Baraga, Houghton, & Keweenaw Counties, MI		
Lake Bailey Marshes	Waterfowl	
Lake Upson Marshes	Waterfowl	
Keweenaw Point & Copper Harbor	Passerine, hawk	
Houghton Area	Waterfowl	
Isle Royale	Herring gull, osprey	
Sand Point Marsh	Waterfowl, shorebird, passerine	
Point Abbaye	Passerine, hawk	
Marquette & Alger Counties, MI		
Mouth of Dead River	Waterfowl	
Chippewa & Luce Counties, MI		
Whitefish Point	Waterfowl, shorebird passerine, hawk	A migration focal point of prime importance.
Mackinac & Chippewa Counties, MI (East to Brush Point)		
St. Martins Shoal	Herring gull, ring-billed gull, shorebird	Migratory route for shorebirds.
Schoolcraft & Delta Counties, MI		
Bay De Noc	Woodcock	Major shorebird migration area.
Portage Point, Escanaba	Waterfowl, shorebirds gulls, terns	Michigan DNR

Table 68 (continued).

Area	Major bird use	Remarks
Peshtigo Point & River	Shorebirds, gulls & terns, passerines, herons, waterfowl, peregrines, & eagles	State of Wisconsin Refuge
Marinette County, WI Sea Gull Bar, Marinette	Shorebirds, gulls & terns, waterfowl, herons, peregrine falcon	Wisconsin DNR scientific area
Oconto River Mouth	Waterfowl, gulls & terns, herons, egrets	
Little Tail Point	Waterfowl & shorebirds	Private
Sensiba Wildlife Area	Waterfowl, terns, herons, egrets, Marsh birds	State DNR owned
Long Tail Point	Waterfowl, shorebirds Peregrines, eagles	FWS (NWR)- state managed
Cat Island Chain (Cat, Grassy, Willow, and Low Tree)	Double-crested cormorants, Canada geese, ducks, black-crowned night herons, ring-billed gulls, common terns, herring gull.	Ownership unknown. Duck hunting occurs on third island.
Duck Creek/Atkinson's Marsh Mouth of Fox River	Waterfowl, passerines, shorebirds, herons, gulls & terns, cormorants, raptors (owls, hawks, eagles, peregrines)	Main migratory focal point on Green Bay. Two shorelines + Fox River Valley intersect here. For endangered species protection, some portions designated natural areas. Heavy development pressure.
Sable Point (Point Au Sauble)	Passerines, waterfowl, shorebirds	Private

Table 68 (continued).

Area	Major bird use	Remarks
Moonlight Bay	Waterfowl, passerine, shorebird, black tern	
Ridges Sanctuary		Privately owned
Marinette, Oconto Brown Kewaunee & Door Counties	Eagles, hawks, owls	T. Erdman estimates 10,000 - 20,000 raptors migrate in this area of NE Wisconsin.
Sheboygan, Manitowoc, Kewaunee, Ozaukec, Milwaukee	Raptors, waterfowl. loons	
Cedar Grove Ornithological Station		Uw-Madison. DNR scientific area and refuge.
Kewaunee River Marsh	Waterfowl, marsh-birds	Important coastal/river marsh.
Manitowoc River Marsh	Waterfowl, marsh-birds	Important coastal/river marsh.
Sheboygan, Manitowoc & Kewaunee Counties, WI		
Cedar Grove Ornithological Station	Passerine, hawk	Connected with University of Wisconsin.
Berrien, Van Buren, Allegan, & Ottawa Counties, MI		
Grand Beach to Warren Dunes State Park	Waterfowl	Major staging areas for diving ducks, loons, grebes, and other water-fowl.
New Buffalo Harbor	Waterfowl, shorebird	Many oldsquaw & other ducks winter here.
Warren Dunes State Park	Passerine	Rare prairie warbler found nesting on shrubby beach areas.

Table 68 (continued).

Area	Major bird use	Remarks
Junction of St. Joseph River & Paw Paw to Mouth	Waterfowl, shorebird	Daytime migration at foot of Higmans Hill, some days 40,000.
Kalamazoo Lake & Saugatuck Marsh	Black tern, waterfowl shorebird, passerine, blue heron	Important marsh nesting habitat. Many migrating species pass through this area. Mainly overwintering diving ducks, but unusual sea and ocean ducks often seen.
Port Sheldon Harbor & Pigeon Lake	Waterfowl	
Grand Haven Marsh Lower Grand River	Black tern, waterfowl, shorebird, passerine, hawk	
Benzie, Manistee, Mason Oceana, & Muskegon Counties, MI		
Muskegon River Mouth & Muskegon State Park	Black tern, waterfowl, shorebird, passerine, hawk	A major sanctuary area, being partly endangered by fly-ash filling by Consumers Power Co. Large hawk migrations.
Big Sable Point & Ludington State Park	Shorebird, passerine, hawk	
Hamlin Lake	Waterfowl	Large goose migration.
Elberta Marsh		
Pentwater River Mouth	Waterfowl, shorebird, passerine, hawk	
Point Betsie Unite Lake	Shorebird, passerine, hawk	

Table 68 (continued).

Area	Major bird use	Remarks
Benzie State Park	Shorebird, passerine, hawk, waterfowl	
Manistee River (mouth)	Waterfowl	
Grand Traverse & Leelanau Counties, MI		
Sleeping Bear Point	Shorebird, woodcock, passerine, hawk	
Sandy Point (South Manitou Island)	Herring gull, ring billed gull, shorebird, passerine	Large passerine migration.
Lighthouse Point & Cathead Bay	Common tern, waterfowl shorebird, woodcock, passerine, hawk	
Greilickville	Waterfowl	
Ptobego Marsh	Black tern, waterfowl shorebird, passerine	
Emmet, Charlevoix, & Antrim Counties, MI		
Harbor Springs	Passerine	
Waugoshance Point	Herring gull, ring billed gull, shorebird	
Shoreline West of Mackinaw City	Shorebird, passerine	One of major spring concentration points for many species. Funnel for whole lower peninsula of Michigan.
Straits of Mackinac	Herring gull, common & caspian tern	Bad erosion.
Hog Island	Woodcock	
Garden Island	Woodcock	

Table 68 (continued).

Area	Major bird use	Remarks
High Island	Herring gull, ring billed gull, caspian tern, woodcock	
Alpena, Preque Isle, & Cheboygan Counties, MI		
Calcite	Herring gull, ring billed gull, common tern, shorebird	
Calcite Flats	Shorebird	
False Presque Isle	Passerine, hawk	
North Point	Passerine, hawk	
Gull Island	Herring gull, ring billed gull, common tern, blue, night & green heron, shore-bird	
Thunder Bay Island	Herring gull, ring billed gull, common tern, shorebird	
Sugar Island	Herring gull, ring billed gull, herons, shorebird	
Grass Island	Herring gull, ring billed gull, common tern, black-crowned & green heron, water-fowl, shorebird	
Sulphur Island	Ring billed gull, black-crowned & green heron, shorebird	

Table 68 (continued).

Area	Major bird use	Remarks
Scarecrow Island	Herring gull, ring billed gull, common & black tern, blue & black-crowned heron	
Thunder Bay River (mouth)	Waterfowl	
Bird Island	Herring gull, ring billed gull, black-crowned & green heron	
South Point	Passerine, hawk	Exceptional concentration of nocturnal and diurnal passerines.
Black River Island Shoals	Herring gull, ring billed gull, common tern, shorebird	
Au Sable Point	Waterfowl, shorebird, woodcock, passerine, hawk	Mainly shorebird migration.
Tawas Point, Tawas Bay and adjacent Lake Huron	Waterfowl, shorebird, woodcock, passerine, hawk	Prime focal point for migration. Two banders average 3,000 per week.
Point Lookout	Waterfowl, shorebird, woodcock, passerine, hawk	
Point Au Gres and Wingman Bay	Waterfowl, shorebird, woodcock, passerine, hawk	
Tuscola & Bay Counties, MI		
Tobico Marsh	Black tern, waterfowl, shorebird, woodcock, passerine, hawk	

Table 68 (continued).

Area	Major bird use	Remarks
Nayanquing Point	Waterfowl	
Fish Point	Waterfowl, shorebird, woodcock, passerine, hawk	
Sanilac & Huron Counties, MI		
Katechay Island Bay	Waterfowl	
Wildfowl Bay	Waterfowl	
Sand Point	Waterfowl, shorebird	
Sebawaing Bay	Waterfowl, shorebird, woodcock, passerine hawk	
Fish Point Little Charity Island	Ring billed gull, shorebird, common & caspian tern, black-crowned night heron	
Charity Island Reef	Ring billed gull, shorebird, common & caspian tern	
Monroe, Wayne, Macomb, & St. Clair Counties, MI		
Dickinsons & Harsens	Waterfowl	Important marsh habitat. Large waterfowl concentrations.
Lower Detroit River	Waterfowl	
Lake St. Clair, Anchor Bay and Flats, St. John's Mouth	Waterfowl	Large waterfowl concentrations.

Table 68 (concluded).

Area	Major bird use	Remarks
Marsh in Pointe Mouillee, State Game Refuge	Common tern, waterfowl, shorebird, black tern passerine, hawk	
Pointe Mouillee	Common tern, black tern, waterfowl, shorebird, passerine, hawk	Particularly important for migrating hawks.
Sterling State Park	Common tern, black tern, waterfowl, shorebird, passerine, hawl	
Mouth of Raisin River	Common tern, waterfowl, shorebird, passerine, hawk	
Point Menilee	Waterfowl, shorebird, passerine, hawl	
Bolles Harbor	Waterfowl, shorebird, passerine, hawk	
Wood Tick Peninsula	Waterfowl, shorebird, passerine, hawk	

[a]Modified from Great Lakes Basin Commission report (1975), supplemented with other published and unpublished data (see Methods).

migration corridors can and have been mapped and reasonable estimates of numbers can be made. Several major references exist which present this information perhaps the most notable being Bellrose (1968, 1978), Johnsgard (1975), and Palmer (1976).

Estimates of the total number of waterfowl which migrate through the Great Lakes region each year exceed three million (Great Lakes Basin Commission 1975). This includes large numbers of diving ducks, dabbling ducks, and Canada geese, as well as lesser numbers of snow geese, blue geese, swans, and coots. The corridors used by these birds are shown for the major groups in Figures 38-40. Essentially the same corridors are used both spring and fall, although the spring migration tends to be more dispersed. Maps for each species are presented by Bellrose (1980).

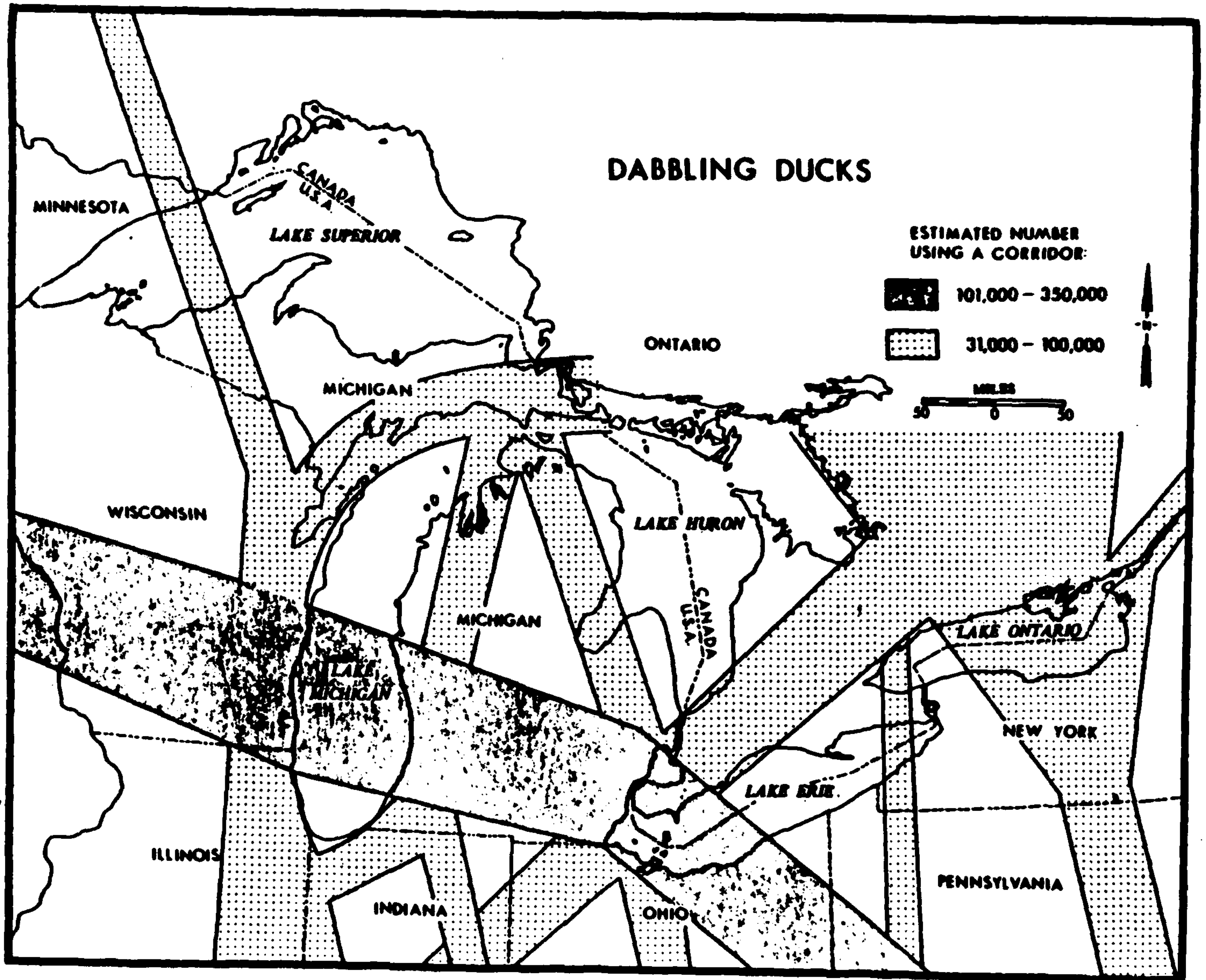


Figure 38. Dabbling duck migration corridors in the Great Lakes Region (after Bellrose, 1968).

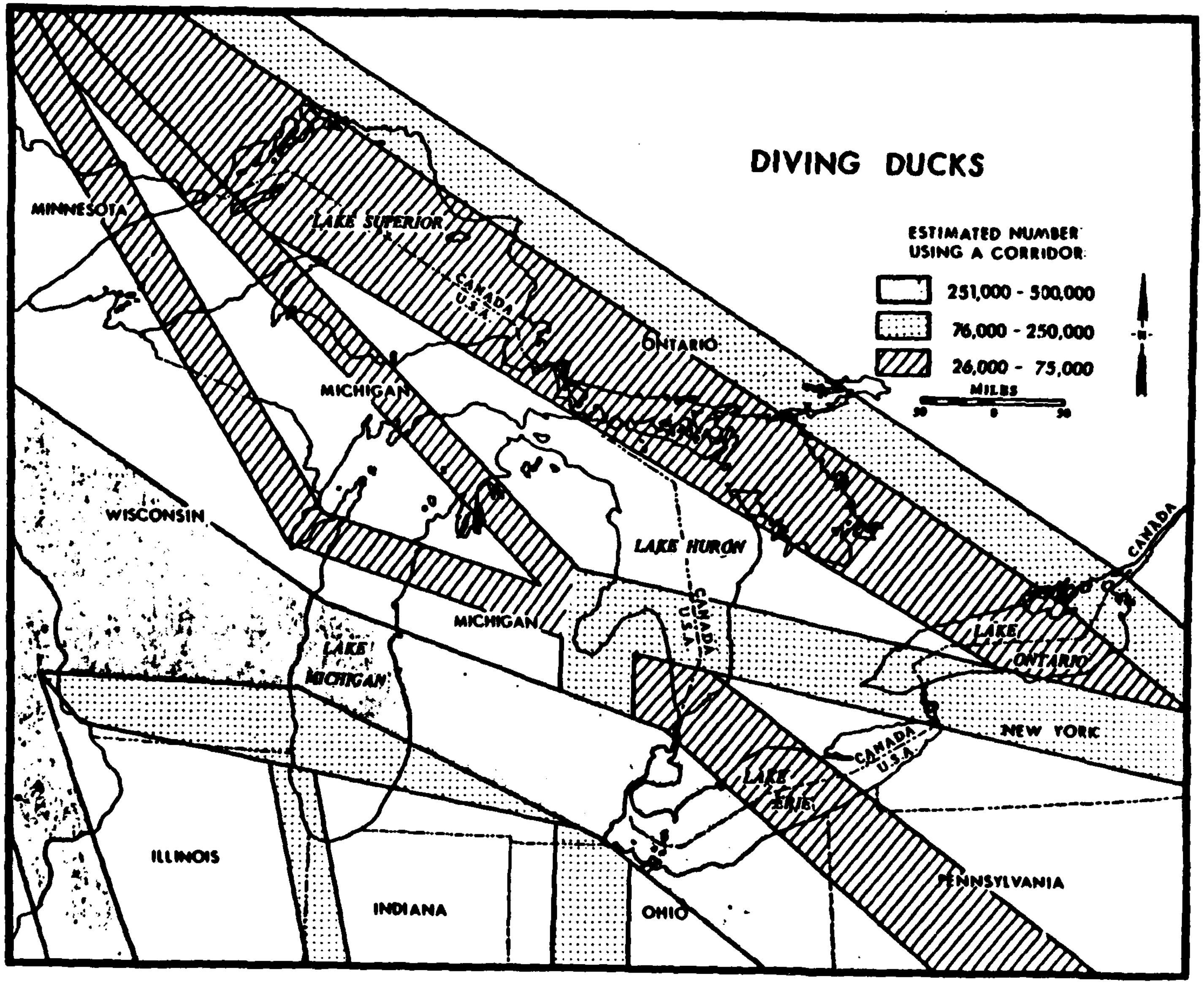


Figure 39: Diving duck migration corridors in the Great Lakes Region (*after* Bellrose, 1968).

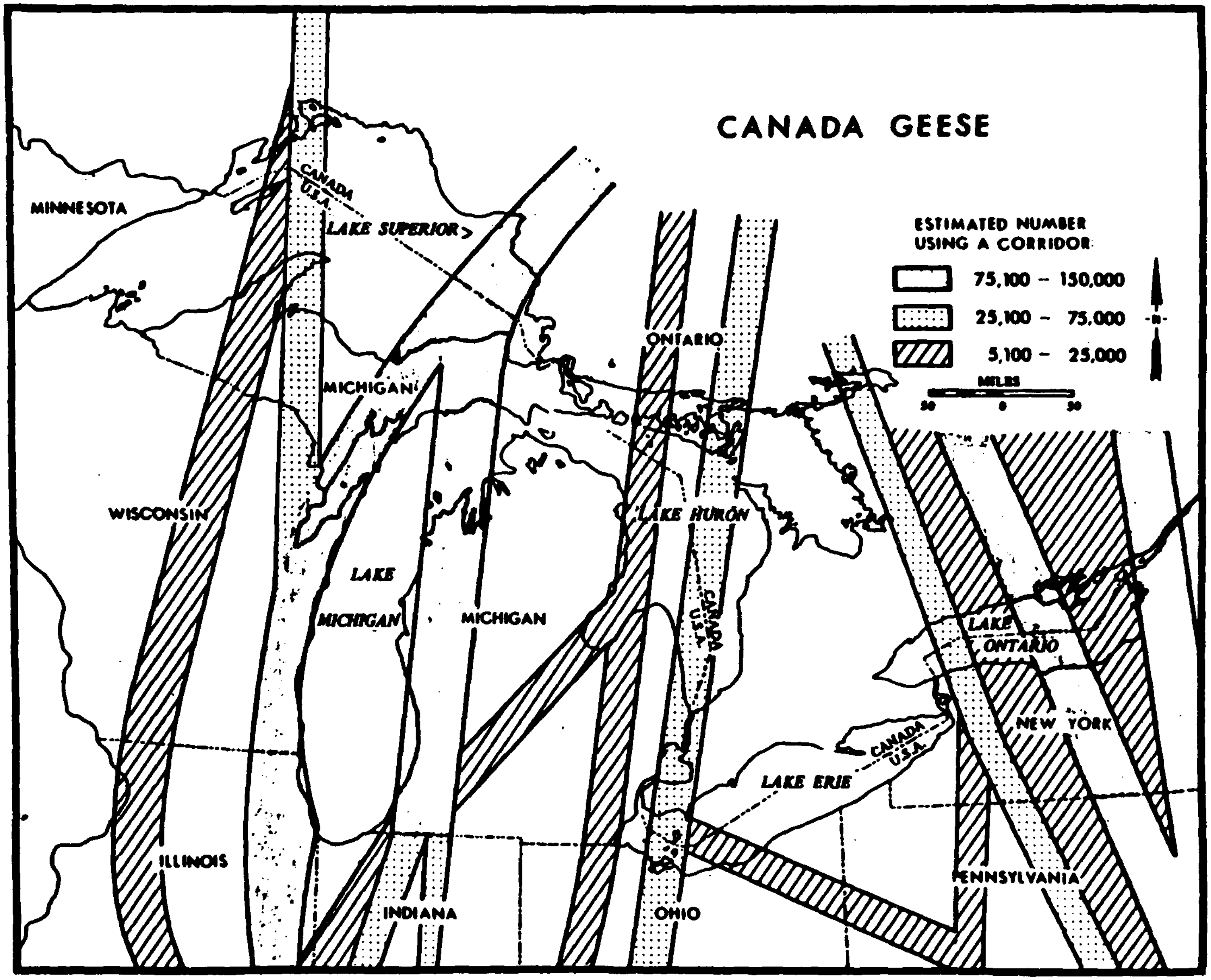


Figure 40. Canada Goose migration corridors in the Great Lakes Region (after Bellrose, 1968).

DISCUSSION

Avian Populations, Distribution, and Habitats

Major Concentrations. Several factors may determine when and where major winter waterbird concentrations occur on the Upper Great Lakes. Of primary importance is the existence of open water for feeding and resting and the presence of a food source. Lack of certain types of disturbance may also be important (Sugden et al. 1974, Hume 1976).

Our findings indicate that these basic requirements, and thus major bird concentrations, are primarily found in areas of major human impact. Indeed, one or both of the primary requirements may be met due to human activity. All the major winter concentrations we documented occurred in such areas including harbors, power plants, sewage outfalls, industrial sites, parks, refuges, and combinations of these.

Human-induced open water primarily results from thermal discharges from power plants, industrial sites, and sewage treatment plants. In some instances these heated waters also result in increased food resources by enhancing aquatic primary and/or secondary productivity (Reed 1971). Sewage discharges, in addition to providing heated water, increases productivity by increasing available nutrients (Cooper and Johnson 1977). There are, however, several instances in which overwintering birds primarily rely on established feeding programs (e.g., Bay Beach Park, Green Bay, Traverse City).

Some of the species which congregate in the above areas probably would overwinter in significant numbers without man's impact, although they perhaps would not occur in such large congregations. These species include the oldsquaw, merganser spp., and gulls. These birds use offshore areas as well as major concentration sites. However, several species appear to overwinter on the Upper Great Lakes primarily due to human impact. These include the canvasback, redhead, scaup spp., swans, mallard, black duck, and Canada goose. As an example, the canvasback and redhead presently occur in large numbers on the Detroit River, but prior to industrial development of the area (1930's) there was little open water and thus few birds during winter.

While almost all of the major concentration sites we documented were used both years of our study, it does appear that other factors, in particular ice, can influence usage. Thus, those sites attracting birds primarily because they offer open water may not be as heavily used in years when adjacent ice cover is minimal.

Spatial/Temporal Variation in Bird Densities. Although we documented winter waterbird populations for only a two year period, it is apparent that there was much variability both with respect to location and time. The populations at some sites were markedly different the two years of our study. Most indicative of this was the Detroit River where early winter waterbird populations were approximately 10,000 and 35,000 in 1979-80 and 1980-81, respectively. Similar variability is evident in past data regarding this site as well as most others for which information is available. It appears that

early winter weather and ice conditions are important determinants in this regard. Other workers have noted this same relationship (e.g., Synder et al. 1974). Additional factors which probably affect the size of overwintering populations are the abundance of food resources, production of young the previous summer, and the disturbance to which the birds are subjected. Variation in winter bird populations has been noted in a number of other studies (Lepthien and Bock 1976, Bock 1980). The primary influence on winter abundance seems to be food resource abundance.

Since weather and accompanying ice conditions have major influence on the size of these populations, it is not surprising that there is significant year to year variation in numbers. Documentation of these parameters on the Great Lakes during past years shows a high degree of variability (Rondy 1971).

In addition to annual variation, seasonal changes in abundance were also marked for some species especially goldeneye and gulls. The former declined markedly after January, while the latter steadily increased throughout the winter months until the major migration occurred (late February to early March). Site-specific populations also varied widely during a given winter. This probably represents intra-lake (or river) movement, although we do not know the limits of these "short range" movements.

Some populations and species also exhibited definite diurnal movements. In some cases these movements represent regular flights between feeding and resting areas. In Green Bay, waterfowl, especially Canada geese, feed in fields during the day, but often rest in the open water at the mouth of the Fox River at dusk and dawn. In the Milwaukee harbor, overwintering scaup have been shown to regularly move between separate resting and feeding areas (Rofritz 1972). These movements can influence aerial survey data.

Weather can also affect daily bird distribution. During our work on the Detroit River, some species seemed to move to sheltered areas in response to brisk westerly winds. Seasonal prevailing winds can affect birds on a regional basis. Winter winds in the Upper Great Lakes tend to be from the northwest or west. Thus eastern and southeastern shores are iced in a greater portion of the year than other areas. This of course directly affects use by species such as goldeneye and mergansers which use nearshore waters.

Shipping Impacts

This section is intended to be both a reiteration and synthesis of the major results described in the foregoing sections as they regard impacts of winter shipping on the birdlife of the Great Lakes. The presentation includes two major subdivisions. The first deals with more generalized issues (e.g., regional impacts on winter bird distribution, bird mortality). While we have for the most part limited our discussion to the specific work objectives of our study, some additional information and concerns regarding impacts on birdlife have been included. This primarily involves issues regarding breeding birds at specific sites. The second section presents our findings on a site by site basis and as such is organized similar to the U. S. Fish and Wildlife Service Coordination Act Letter Report (U. S. Army Corps of Engineers 1979).

It is important to note beforehand that the winter navigation demonstration program ended prior to initiation of our study. Thus little inter-lake shipping took place, and our assessment of impacts was greatly limited. In addition, shipping schedules for intra-lake movements were not readily available, further hampering our planning and limiting observations of the effects ship passage had on birds, ice, etc. For these reasons, much of our assessment takes the form of concerns extrapolated from information which must be considered "baseline."

Our studies were further limited in that they encompassed only a two-year period. In this short time it is quite difficult to adequately account for year-to-year variability in factors such as weather, ice, cycles in bird populations, etc. This interpretation must be conservative and, although desirable, modeling of the impacts on winter shipping on bird populations must similarly be limited.

A final limitation in much of our work is that separating the effects of winter and summer shipping and high water levels is difficult. This is especially true of our studies examining impacts on wetlands and colonial bird nesting sites. With minor exceptions the study sites involved have been subjected to both types of shipping, and those on the St. Mary's have been subjected to high water levels also.

General Impacts. Several potential impacts of extending the navigation season upon birdlife were outlined in the Survey Study (U. S. Army Corps of Engineers 1979). These can be separated into two major classes, those impacts which could be termed acute, i.e., would affect winter bird populations on an immediate basis, while the latter includes those impacts which would have a delayed effect.

The major effects of winter shipping which have been recognized as having potentially acute impacts include: (1) creation of additional open water areas, (2) reduction in available food, (3) disturbance of birds due to shipping activity, and (4) chemical/oil spills.

The first of these is of concern since open water areas may cause additional waterbirds to overwinter. Previous studies of overwintering waterfowl (e.g., Sugden et al. 1974) indicate that three main factors may influence the size of winter populations: the amount of open water, the availability of food, and the amount of disturbance to which the birds are subjected. These factors are most important during the late fall/early winter period when migrants are still present in a given area. Certainly there is much interplay between these, and what role they play in a given situation is hard to predict.

It does seem that at least some of the above factors are important in determining the size of winter waterbird populations on the Upper Great Lakes. Our work indicates that the annual variation in these populations may be quite high, especially on a site by site basis and it appears that early winter weather is important in this regard. This was quite evident in the Detroit River areas where nearly 40,000 waterbirds were observed in January 1980 and less than half that many were seen in January 1981. This large difference primarily reflects the comparatively mild early winter and concomitant lack of ice on the river in 1980. Similar fluctuations with

weather have been noted in the past (G. Martz, personal communication). Thus, the amount of open water present at a given site may be important, and creation of additional open water areas (via air bubblers in harbors, etc.) could greatly affect both numbers and distribution of waterbirds which overwinter in the Upper Great Lakes.

Activities encouraging waterfowl to winter north of their normal range have been discouraged by a number of agencies including the Mississippi Flyway Council. Reasons for this include fears that food resources may not be adequate to sustain the birds throughout the winter, and that artificially induced open water areas may not remain open throughout the winter, effectively making food unavailable to the birds. Additional concerns with respect to open water created by winter shipping activities are chemical/oil spills and disease outbreaks areas of concentrated bird. Events of both types have been recorded on the Detroit River (Hunt 1961, Hunt and Cowan 1963).

Several activites associated with winter shipping may create additional open water areas. These include ice-breaking, operation of bubblers, vessel passage, and placement of ice booms. We have addressed the potential for adverse impacts of these activities on a site by site basis in the following section. In many instances, since present winter populations are low despite the presence of open water, it seems unlikely that additional waterbirds would be attracted by small increases in open water. Exceptions to this would be sites in which the open waters caused by shipping result in a significant increase in available food. Our work did not examine this possibility, and it seems worthy of study on a select site basis especially in harbors with significant fall migratory populations.

Relevant to the above concern is the general health and status of overwintering birds. We examined birds overwintering on the lower Detroit River and in general found that they were in poor condition. Previous work by other investigators (e.g., Hunt 1957) regarding this area noted the same mortality due to starvation has ranged as high as 56% on the Detroit River. These losses were attributed to reduced food availability due to increased ice cover. Thus the potential for adverse impact definitely exists. We are not aware of information regarding the health and status of energy reserves of waterfowl in other areas of the Upper Great Lakes. This seems worthy of study, especially in areas of major concentrations such as Milwaukee.

The other potential acute impact of winter shipping on birds which our work addressed is diturbance. The primary concern here is that vessel passage will force birds to move repeatedly, and that this may contribute to already-reduced energy reserves. Since no winter shipping occurred during our studies, we could not directly observe waterbird responses to passing vessels or to examine birds subjected to this impact. Our work on the Detroit River and our aerial surveys, as well as Robinson and Jensen's (1979) study of the St. Mary's River strongly suggest that birds do not use shipping lanes.

This does not necessarily imply that there is no impact. Although Robinson and Jensen (1979) suggested little direct impact by winter ship traffic on waterfowl and eagles in the St. Mary's River, they also note the avoidance of the ships by as much as 1 km by bald eagles. This study was qualitative in nature and occurred during a year of only light winter traffic; it therefore should not be considered conclusive.

Others have reported bird reaction to shipping traffic. Rofritz (1972) noted that recreational boating in Milwaukee in fall and early winter had a pronounced effect of the distribution of migratory waterfowl using the area. The birds repeatedly avoided boat traffic and temporarily abandoned feeding areas to do so. Cronan (1957) also noted movements of feeding scaup in response to pleasure boaters. G. M. Haramis (personal communication) has noted little response of diving ducks (esp. canvasbacks) to large ships in the channels in the Chesapeake Bay but strong responses to small commercial fishing boats operating nearby. M. C. Perry (personal communication) has witnessed flight responses of wintering canvasbacks to barges and tugs on the Mississippi River. Important variables impinging on the response are certainly boat distance and noise and the physical condition of the birds.

The other aspect of our work which addressed direct impacts on waterbird populations was the Beached Bird Survey (BBS). Once again, we could not examine actual impacts of an extended shipping season since essentially no inter-lake shipping occurred during our study. We did however examine the effects of various factors on mortality. Most pertinent of these to winter shipping impacts was an analysis of mortality, as indicated by beached bird rates, in relation to harbor status (active or inactive). We found no significant effect in this regard. However, generalizing this result to imply that winter shipping would not have an effect on bird mortality is unjustified since the effects of the various activities (e.g., operation of bubblers) associated with the extension of the season have not been assessed.

The major long-term impacts that winter shipping may have on birdlife may be put into two major categories: 1) breeding habitat losses and 2) food resource losses. We examined the first of these in our studies of wetlands and colonial waterbird nesting sites. Wetlands were studied in both Duluth and the St. Mary's River, and colonial nesting sites were studied on the St. Mary's River only.

Our findings differed considerably in these two areas in that we found little evidence of impact in Duluth, but strong indications that shipping, both summer and winter, has contributed to significant erosional losses in the St. Mary's River. This certainly points out the inherent site-specific differences in impact, but also that winter shipping can indeed result in losses of habitat important to birdlife.

The loss of wetlands is especially crucial. This habitat type is not only valuable as breeding/feeding habitat for a wide variety of birds, but also is a highly productive biological system overall. Wetlands in general are difficult to replace. Natural regeneration time is at least an order of magnitude longer than for many terrestrial habitats. In addition, wetlands have been disappearing at a rapid rate throughout the Great Lakes (Jaworski and Raphael 1977), as well as throughout the United States.

The loss of small river islets may not seriously reduce productivity in the region but may be critical for certain avian species, such as the declining common tern in the St. Mary's River. This species, in many parts of its range, is often outcompeted by other gull species.

Site Assessments

Lake Superior Harbors

Silver Bay

Bird use of this harbor is minimal during all seasons, and it does not appear to have any outstanding or unique values with regard to avian species. We cannot foresee any adverse impacts on birdlife due to extension of the shipping season as outlined in the Survey Study. The only endangered bird species which may use the area are the bald eagle and peregrine falcon, but they occur only as rare migrants and are not specifically associated with or dependent upon the harbor or adjacent waters.

This harbor is completely ice-covered most of the winter, and the proposed operation of a 200C' bubbler could produce some open water. However, since migratory and winter bird use of this harbor and the adjacent Lake Superior shoreline are sparse, and the nearby shoreline areas remain ice-free much of the winter, it seems highly unlikely that additional waterbirds would be induced to overwinter.

Taconite Harbor

Bird use of this harbor is minimal during all seasons, and it does not appear to have any outstanding or unique value with regard to avian species. We cannot foresee any adverse impacts on birdlife due to extension of the navigation season as outlined in the Survey Study. The only endangered bird species which may use the area are the bald eagle and peregrine falcon, but they occur only as rare migrants and are not specifically associated with or dependent upon the harbor or adjacent waters.

Two Harbors

Bird use of this harbor is minimal during all seasons, and it does not appear to have any outstanding or unique values with regard to avian species. We cannot foresee any adverse impacts on birdlife due to extension of the navigation season as outlined in the Survey Study. The only endangered species which may use the area are the bald eagle and peregrine falcon, but they occur only as rare migrants and are not specifically associated with or dependent upon the harbor or adjacent waters.

Duluth-Superior

Winter bird use of this harbor is minimal, and thus immediate impact of extension of the shipping season on birdlife in unlikely. The area is ice-covered during the winter with the exception of small patches near a power plant, wastewater treatment plant, and the two entrys into the harbor. Thus, the proposed operation of a number of bubblers could result in a significant increase in the amount of open water present, and it is possible that this could induce additional birds to overwinter, especially migratory waterfowl which occur in significant numbers during the fall. However, the sparse use

of present open water areas indicates that this is unlikely to occur. We do agree that bubblers be operated such that some ice cover is maintained in these areas, especially in early winter when migratory waterbirds would still be present. If such a tactic proves costly or difficult to realize, a short-term study to determine if additional birds are attracted by bubbler induced open water is recommended. Such a study would quickly determine if adverse impacts occur. Ship passage and ice-breaking activities could also create open water areas in this harbor, but observations during our study and others indicate that ship tracks close over almost immediately and should not be of concern in this regard.

The more likely impacts of winter shipping on birdlife in this harbor are more indirect and fall into the categories of habitat and food base losses affecting migratory and breeding birds of the area. As noted above, large numbers of waterbirds, including the endangered bald eagle, utilize this harbor during migration. Previously outlined concerns regarding potential destruction of benthic communities and fish populations (U. S. Army Corps of Engineers 1979) imply potential adverse impacts on the food resources of these species could occur.

While we did not study effects on the benthos in the Duluth-Superior Harbor, we did examine potential impacts of this sort on the Detroit River. We were not able to directly observe effects of winter navigation on benthic macroinvertebrate and plant communities in the Detroit River because of the aforementioned problems with shipping schedules, etc., but our study did allow potential threats to be identified, and these may well apply to the Duluth Harbor also. These are discussed in the DETROIT RIVER site discussion.

One of the major concerns outlined in the U. S. Fish and Wildlife Service Letter Report related to this topic was the resuspension of bottom materials and potential for accompanying oxygen depletion and large winter fish kills. This is of particular concern regarding breeding birds in the harbor since several colonial species which nest in the harbor depend to varying degrees on this fish population. Of special concern is the common tern which has undergone serious population declines throughout the Great Lakes and is presently on the endangered species list of the state of Wisconsin. The Duluth-Superior Harbor presently supports nearly 70% of the known Lake Superior breeding population of this species (Davis and Niemi 1979). Other colonial species which could be affected if the fish population in the harbor was seriously depleted include the great blue heron, the ring-billed gull, and black tern.

Since completion of the Letter Report, the Western Lake Superior Sanitary District wastewater treatment plant has gone into full operation. This has greatly reduced organic loading in the harbor waters; however, little work has been done to determine if the status of bottom sediments has or is changing due to this. Thus the above concerns remain critical and we strongly urge that a study of this potentially serious problem be conducted.

Our studies in the Duluth-Superior Harbor did include an examination of real or potential losses and impacts on one critical habit type wetlands. A detailed discussion of these findings is presented in the BREEDING BIRDS portion of this report. In essence, we could not demonstrate that the winter shipping

which took place in this harbor during the demonstration program had any effect on wetlands. This reflects several factors. Firstly, few wetlands remain in the lower harbor due to previous dredging and shipping activity and those that do remain are not immediately adjacent to ship traffic. Secondly, little winter shipping actually occurred in this harbor during the demonstration program and thus impacts, if they occurred, were probably minimal. Finally, these wetlands are and have been exposed to summer shipping also, hence, separation of seasonal effects is difficult at best.

We do not feel that future extension of the shipping season would adversely affect these marshes or the breeding bird populations utilizing them. This is based on present plans as outlined in the Survey Report. The major concern in this regard pertains to the extensive wetlands in Allouez Bay. These marshes are some of the most valuable in the entire St. Louis River estuary. Present plans do not include activities which we feel would adversely affect this area, but modifications which would bring vessel routes appreciably closer to this area would be viewed as unacceptale.

Ashland

Winter bird use of this harbor and nearby areas of Cheguamegon Bay is minimal, thus immediate impact of extension of the shipping season as described in the Survey Study is unlikely. The area is ice-covered during the winter with the exception of small patches near the power plant and at the mouth of Fish Creek. Thus, the proposed operation of a 1000' bubbler could result in a significant increase in the amount of open water present, and it is possible that this would induce additional birds to overwinter, especially migratory waterfowl which occur in moderate numbers during the fall. However, the relative lack of use of present open water areas indicates that is unlikely to occur. Perhaps the species of most concern in this regard would be the bald eagle. This species nests in the region and has been reported on Christmas Counts in the Fish Creek area. However, local observers do not feel any individuals overwinter, and additional open water areas probably would not alter this situation. In addition, recent work in the State of Michigan indicates that bald eagles are not as dependent upon open water areas in the winter as previously thought and utilize road kills to a great extent. Although we do not feel that additional open water at the bubbler site would have adverse impacts on birdlife, we agree that bubblers should be operated such that thin ice is maintained in these years, especially in the early winter when migratory birds are still in the area.

The more likely impacts of winter shipping on birdlife in this harbor are more indirect and fall into the categories of habitat and food base losses affecting migratory and breeding birds of the areas. These concerns were outlined in the U. S. Fish and Wildlife Letter Report (1979). Our work did not include a study of these effects in this harbor, although we concur with the concerns expressed. Since completion of the foregoing document, successful efforts have been made to provide nesting habitat for common terns in this harbor (Mossman, <u>personal communication</u>). The common tern population has undergone serious declines throughout the Great Lakes and is on the endangered species list for Wisconsin. The species relies heavily on fishes as a food resource and the above concerns relating to ship passage and impacts on the fish population of the area thus have implications regarding this species.

Marquette/Presque Isle

Bird use of these harbors is minimal during all seasons and they do not appear to have any outstanding or unique values with regard to avian species. We cannot foresee any adverse impacts on birdlife due to extension of the shipping season as outlined in the Survey Study. The only endangered species which may use the area is the bald eagle, but it occurs only rarely on Christmas Counts. It does not appear that the species overwinters here.

Ice conditions in the harbors are quite changeable. During times of maximum ice, open water does remain at the Shiron power plant and in the lower Dead River. These areas are used by the few overwintering birds (gulls and waterfowl). The proposed operation of a 1000' bubbler at Marquette could result in a significant increase in open water in the harbor during portions of the winter, but its location immediately adjacent to existing open water at the power plant and the fact that open water exists in the lower Dead River make it seem unlikely that this would induce additional birds to overwinter.

The major winter bird use of this area is the lower Dead River in the Presque Isle harbor. Use of the Marquette Harbor is primarily limited to gulls which congregate at the power plant site. For this reason, if a choice as to which of the two harbors to use were to be made, we would recommend Marquette. This would avoid any added disturbance to the waterfowl and occasional bald eagle using the river area. However, this recommendation is not a strong one since little bird use actually occurs in the area anyway.

St. Mary's River

Winter waterbird use of this area is moderate (500-1000 individuals) although the endangered bald eagle has been known to use the area regularly in recent year. since year-round shipping did not occur during our study, we could not assess immediate impacts on these birds. However, Robinson (1979) did so during the winter of 1978-79. He observed no significant effects, although the two bald eagles present did avoid shipping traffic. This study was qualitative in nature and occurred during a winter of light shipping, it therefore cannot be viewed as conclusive. More quantitative work regarding disturbance by ship passage is recommended, in particular during a heavy shipping winter.

Our work in this area focused on habitat losses and specifically assessed effects on wetlands and colonial bird nesting sites. Details of our findings are presented in the BREEDING BIRDS section of this report.

Our wetlands study did not indicate any obvious impacts on breeding bird populations, but possible impacts were evident with respect to vegetation. In particular, species richness in shoreline areas was lower in marshes near shipping lanes and it appeared that some erosional losses have occurred. Lower diversity is in general expected in systems under high stress. In this case it appears that scouring and erosion due to ship wakes limits the species able to maintain a population in the shoreline of the marshes. We were unable to determine to what extent this phenomeonon was due to winter shipping as opposed to summer shipping since most of the marshes have been exposed to both. It

seems likely that both have contributed to this problem. Previous observations by U. S. Fish and Wildlife Service personnel verify that erosion can be caused by vessel passage in the St. Mary's River (Poe et al. 1979). This impact would be expected to continue if extended navigation seasons are initiated. It is a localized effect, but does represent losses of a habitat type important to breeding and migratory birds which has undergone significant losses throughout the Great Lakes.

Our work with colonial species shows that island sites near shipping lanes are experiencing significant losses due to erosion also. These sites are used as nesting areas by ring-billed gulls, herring gulls, and common terns. The latter species is of special concern since it has undergone significant population declines throughout the Great Lakes in recent years.

As with our wetlands work, we could not separate the effects of summer and winter shipping since most nesting sites have been subjected to both. Furthermore, recent high water levels on the St. Mary's River appear to have played a significant role in these habitat losses. Although we could not quantify the contribution of the above components, we are sure that winter shipping has and would be a significant contributing cause in these erosional losses of important nesting habitat. Mitigating procedures which could not only minimize the impact of winter shipping, but also that of summer activity, seem feasible. The most straightforward of these would be deposition of additional dredge material at the eroding sites. If done properly, this could provide good nesting habitat on an ongoing basis. Such procedures have proved feasible in other areas (Soots and Landin 1978). We recommend such a plan be devised and implemented in the St. Mary's River.

Lake Michigan Harbors

Escanaba

Winter bird use of this harbor and adjacent portions of Lake Michigan is minimal, and immediate impacts due to extension of the shipping are therefore unlikely. The bald eagle has been seen during the winter months both near Escanaba and in other portions of Little Bay de Noc. The harbor and adjacent portions of Lake Michigan are frozen during the winter with the exception of the power plant site and portions of the Escanaba River and winter bird use is confined to these areas. The proposed operation of several bubblers could significantly increase the amount of open water available and thus could induce additional waterfowl to overwinter. The sparse use of present open water areas indicates this is unlikely, but we concur with the recommendation that bubblers be operated such that some ice cover remains, especially in early winter when migrants are still present. The common tern, a species which has experienced a marked population decline throughout the Great Lakes, does not nest near Escanaba, but present plans do not appear to pose any threat in this regard.

Green Bay

The City of Green Bay and Green Bay itself are significant bird use areas during all seasons. The entire area is used by large numbers of birds during both migratory seasons, and is of particular importance to waterfowl, shorebirds,

and raptors. Breeding bird use of the area is also noteworthy. Several species of special concerned interest nest near Green Bay, in particular in wetlands and on small islands near the mouth of the Fox River, including the double-crested cormorant, black tern, snowy egret, common tern, and Forster's tern. Some of these species have undergone significant population declines in the Great Lakes in the last decade and have been classified endangered in the State of Wisconsin. The snowy egret colony is the only one on the U. S. Great Lakes.

Winter bird use of Green Bay and the Fox River system is significant. Several hundred waterfowl use the open water areas at the Pulliam power plant and on the river, although they seem to rely most heavily on feeding by residents for their food. Lower Green Bay is ice-covered throughout the winter and proposed icebreaking activity and vessel pasage could produce temporary open water areas, but our work and others indicates these "tracks" close quickly in heavy ice such as Green Bay experiences. This, it seems unlikely that extension of shipping season would induce additional waterfowl to overwinter.

The more likely immediate impact on wintering birds would be disturbance. Since no winter shipping occurred at Green Bay during our study, we could not evaluate this potentially adverse impact. We do concur with the suggestion that vessel passage could result in critical energy losses to some of these birds, although the reliance of some species upon artificial feeding at the Bay Beach Park Wildlife Refuge minimized this concern for them (mallards, black duck, Canada geese). These species do use the open water at the Pulliam Power Plant as a resting area at dawn and dusk and certainly would be displaced by vessels in the area. Species not fed at the refuge, e.g., mergansers and goldeneye, would seem more susceptible to energy losses due to this activity, but they tend to use upriver areas more than the immediate harbor.

By far the greater concerns regarding the extension of the navigation season relate to potential destruction of the benthos or/and concomitant losses in food resources (e.g,, fish) important to the breeding and migratory birds using lower Green Bay. We adamantly concur with the concerns outlined in the Letter Report (U. S. Army Corps of Engineers 1979). In addition, we are greatly concerned about erosional effects of ship passage on the small dredge islands presently used as nesting sites by common terns and cormorants. Our work on the St. Mary's River indicates that winter vessel passage may greatly exacerbate the erosion of dredge islands near shipping lanes as is the case in Green Bay. Loss of these sites is highly undesirable. Relocation of the shipping lane could greatly alleviate this problem.

Port Washington

Bird use of this harbor is insignificant during all seasons with the exception of moderate numbers of waterfowl and gulls which occasionally are present during the winter months. It does not appear to have any outstanding or unique values with regard to birdlife. The harbor and adjacent waters of Lake Michigan remain open much of the winter. We concur with the concerns outlined in the Letter Report (U. S. Army Corps of Engineers 1979), although our work did not directly address those issues. The major waterfowl use occurred throughout the outer harbor (inside the breakwater) and depended upon

wind and ice conditions. We cannot make any recommendations as to preferred ship passage lanes to miminize potential impact on these birds.

Milwaukee

Bird use of this harbor is high (in the thousands) during the migratory seasons as well as during the winter months, and Milwaukee is certainly one of the most important waterfowl wintering sites on the Upper Great Lakes. The major winter use areas are the mouth of the Milwaukee River and areas along the shoreline adjacent to it. Since no improvements are needed for winter use of this harbor, the main potential impacts derive from ship passage. Ice conditions in the harbor are quite variable, but the aforementioned bird use areas tend to remain open throughout the winter. Vessel passage should not significantly alter the amount or location of open water present. However, accompanying disturbance causing birds to use energy reserves could be a factor. Rofritz (1972) states that winter waterfowl in this harbor react strongly to recreational boating. This would suggest that ship passage may have this effect also. However, it remains unknown as to whether this would adversely affect the birds. The harbor is highly polluted and wintering waterbirds feed primarily on sludge worms and clams. These food sources appear to be plentiful and this should minimize the dangers of energy depletion of the birds from repeated forced movements. The effect of ship traffic on the availability of the above foods remains an unknown but important consideration also. We recommend that these factors and the general condition of overwintering waterfowl be examined. This would allow a more meaningful assessment of potential adverse effects to be made.

Chicago

Bird use of this harbor is minimal during all seasons and it does not appear to have any unique or outstanding values with respect to birdlife. We cannot foresee any adverse impacts on birdlife due to extension of the navigation season as presented in the Survey Study.

Burns Waterway

Bird use of this harbor is minimal during all seasons, and it does not appear to have any unique or outstanding values with respect to birdlife. We cannot foresee any adverse impacts on birdlife due to extension of the navigation season as outlined in the Survey Study.

Gary

Bird use of this harbor is minimal during all seasons and it does not appear to have any unique or outstanding values with respect to birdlife. We cannot foresee any adverse impacts on birdlife due to extension of the navigation season as outlined in the Survey Study.

Calumet

Bird use of this harbor is minimal during all seasons, and it does not appear to have any unique or outstanding values with respect to birdlife. We cannot foresee any adverse impacts on birdlife due to extension of the navigation season as outlined in the Survey Study.

Indiana Harbor

Bird use of this harbor is minimal during all seasons, and it does not appear to have any unique or outstanding values with respect to birdlife. We cannot foresee any adverse impacts on birdlife due to extension of the navigation season as outlined in the Survey Study.

Muskegon

This harbor is a major bird use area. Large numbers of waterfowl, passerines, shorebirds, and raptors migrate through here, and the wetlands provide waterbird nesting sites. Nearby settling ponds located a few miles upriver serve as a major resting area for migratory waterfowl. Winter use is primarily confined to the open water associated with the generating plant and adjacent Muskegon River, although open water at the entry is also used. Several thousand birds, the majority being common mergansers and gulls, use the area. Recent surveys indicate this general area is used by several overwintering bald eagles also.

The potential for direct impacts due to the extension of the navigation season in this harbor is primarily related to creation of additional open water and distrubance to birds present. Since large numbers of waterbirds migrate through the area, increased open water, formed as a result of placement of ice booms could induce additional birds to overwinter. While our studies did not examine this directly, it appears that the species most likely to be involved would be the common merganser. This species is primarily dependent upon fish for food and at present utilizes the power plant site and the Muskegon River. It seems unlikely that additional open water formed by ice booms would cause a significant increase in the overwintering population. Furthermore, our work shows that the species utilizes open shoreline areas to a great extent. Thus alternate feeding areas are readily available. Disturbance by passing vessels could cause critical energy losses in these birds, although no work has been done to examine the status of the birds in this regard. The major possiblity for disturbance exists at the power plant site, and eliminating traffic at the far east end of the lake would minimize any potential for this impact.

Ludington

Winter bird use of this harbor is minimal and immediate impacts on birdlife therefore seem unlikely. the area is used by moderate numbers of waterfowl during fall migration and the placement of ice booms could result in additional open water which may induce some of these birds to overwinter. The

lack of use of present open water areas suggests this is unlikely. Our observations indicate that open water caused by passage of car ferries in the outer harbor does not persist any length of time. This and other observations of vessel movements made during our study and others suggests that operation of icebreakers and ship traffic do not have a potential impact in this regard.

Traverse City

Winter bird use of the immediate Traverse City area is moderate. It primarily includes several hundred mallards and mute swans. These birds are fed by residents and the swans in particular would probably not survive were it not for the feeding. The lower portions of the bays are frozen from early winter on, although much open water remains in the upper portions. The above birds congregate near and on the Boardman River and at the Holiday Inn where they are fed. While the proposed icebreaker mooring facility and associated vessel passage probably would cause forced movement of the birds, and this would result in energy losses, the fact that the birds are fed by residents minimizes the potential for adverse impacts in this regard.

Lake Huron Harbors

Alpena-Thunder Bay

Winter bird use of this area is minimal with the exception of a few hundred mallards and Canada geese which remain within the city and are fed by residents. Much of Thunder Bay is frozen throughout the winter and, with the above exceptions, waterbird use is limited to a few goldeneye and mergansers which habituate the small open areas on the Thunder Bay River. We cannot forsee any immediate impacts on birdlife due to extension of the navigation season as outlined in the Survey Study.

Bay City-Saginaw Bay

Much of Saginaw Bay is covered during the winter. The only major waterbird use occurs at the J. C. Weadock Power Plant located at the mouth near Bay City. Up to several thousand birds, including common mergansers, mallards, and black ducks use this site. We cannot foresee any immediate impacts on these birds due to extension of the navigation season as outlined in the Survey Study.

Detroit-St. Clair System

This area is probably the most important waterbird overwintering site on the Upper Great Lakes. In addition, Lake St. Clair is recognized as a critical migratory stopover for waterfowl. Thus impacts due to extension of the navigation season are of great concern here. These have been detailed in the U. S. Fish and Wildlife Letter Report (U. S. Army Corps of Engineers 1979). Our study concentrated on bird use of the lower Detroit River and in particular on food resources and distribution.

Details of our findings are presented in the foregoing section of this report. In summary, we found that winter navigation could pose a serious threat to overwintering waterfowl for three major reasons: 1) Ice-breaking activities could cause ice to be diverted to areas that were previously ice free during winter. Areas that are susceptible to being covered by diverted ice include important foraging sites for wintering waterfowl. This could decrease waterfowl food availability. 2) Winter shipping may adversely affect food abundance by the resuspension of fine substrates. The coarser substrates left behind could limit important waterfowl foods. 3) There is evidence that waterfowl wintering on the Detroit River depleted their endogenous energy reserves even when critical shallow water depths were available for feeding. Any loss of feeding habitat due to long periods of ice cover may force major portions of the population to either migrate when lipid reserves are low, or starve to death.

RECOMMENDATIONS

In this section, each of the major concerns and recommendations from the USFWS Coordination Act Letter Report (Appendix I) which are cogent to the results reported here are discussed. To some extent, this will overlap with the brief discussion in the site assessments given above under DISCUSSION.

Letter Report Concerns and Recommendations

A-1. Icebreaking. From the information we obtained, the major areas of concern are the connecting channels, especially the Detroit and St. Mary's Rivers. In these areas, ice could be displaced to shallow water areas heavily utilized by waterfowl, causing scouring and excessive perturbation of benthos.

Also, along the St. Mary's River, there is reason for concern because of erosion of both small riverine islands (both man-made and natural) and shore marshes. Ice breakage should be restricted to areas as far from wetlands as possible. Wetlands of all types are diminishing at a rapid rate nationally.

A-2. Icebreaker Mooring Improvements. The major concern here is the impact of dredging access channels on water quality and the associated floral and faunal resource base for migrating and wintering waterbirds. The Milwaukee and Detroit sites should be approached with the greatest caution because of their significance to wintering birds. At Traverse City, the feeding program would probably mitigate impacts upon wintering waterfowl.

A-3. Vessel Traffic Control. Not relevant.

A-6. Aids to Navigation. The construction of large permanent navigation aids could actually benefit waterbirds by providing nesting habitat. Terns, gulls, and cormorants have been found nesting on such structures in other areas.

A-7. Ice Control Structures. The major concern with the use of such structures in the connecting channels is with changing water levels and their associated impact upon erosion of islands and wetlands. Also, mud anchor dredging could adversely affect benthos in shallow water areas if disposal isn't properly managed.

A-8. Air Bubbler Systems. The operation of bubblers is not expected to significantly affect waterbirds during winter, especially if open waters are limited to do docking areas. Open water, in itself, did not necessarily attract waterbirds. Probably most important are rich patches of benthic organisms and/or aquatic vegetation (see BENTHOS section).

A-11. Dredging. Major dredging activities in the St. Mary's River could drastically alter the river in two ways - water level changes and alteration of water quality and bottom characteristics. "Natural" water level changes could mask the former effect. Changes in the water quality would be expected to affect birds most strongly during non-winter periods since waterbird numbers are not dense in winter. Significant numbers of waterbirds (common terns, gulls, herons) nest along the river in spring, however, and depend upon fish productivity. If dredging were required, however, one mitigating procedure would be the disposal of materials on the rapidly eroding islands. These islands are important nesting sites, especially for the threatened common tern. A similar situation exists in southern Green Bay, Wisconsin.

A-12. Compensating Works. Same concerns as in A-2, A-6, A-7.

A-13. Shoreline Protection. Any structures to "protect" shorelines, especially marshes, could cause even more harm by causing bottom erosion and changed circulation patterns. Major wetlands of concern are along the connecting channels and at Milwaukee and Muskegon Harbors.

A-17. Vessel Speed Control. The concerns here are the same in winter as in summer.

A-19. Vessel Operating and Design Criteria. N/A.

A-21. Oil and Hazardous Substance Contingency Plans. The increased risk of spills during the hazardous winter period is of major concern but we can only address this by noting very low mortality and low incidence of "oiling" of birds in the 1977-80 period (see GREAT LAKES BEACHED BIRD SURVEY section).

A-23. Pilot Access. N/A.

Our overall recommendation is that icebreaking be restricted as much as possible from areas with extensive wetlands or islands suffering high erosion rates. Further, dredging should not be permitted in those areas of the Milwaukee and Muskegon Harbors or the Detroit and St. Mary's Rivers where winter birds congregate or where significant members of waterbirds nest in the spring and summer.

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APPENDIX A. SOURCES OF HISTORICAL INFORMATION REGARDING WINTER BIRD USE OF THE GREAT LAKES

Table A1. Libraries and Various Governmental Offices Contacted as Part of Literature Search.

Libraries

University of Michigan
- School of Natural Resources
- Great Lakes Research Division
- Sea Grant
- Wilson Library

Michigan State University

University of Wisconsin, Madison
- Wildlife Library
- Sea Grant

University of Wisconsin, Green Bay
- Main Libraries
- Sea Grant
- Center for Great Lakes Research (Milwaukee)

University of Minnesota, Minneapolis-St. Paul
- Main Libraries
- Center for Great Lakes Research

University of Minnesota, Duluth
- Main Libraries
- Lake Superior Basin Studies Center

Great Lakes Basin Commission

Governmental Units

Federal

- U. S. Fish & Wildlife Service
  - Green Bay Field Office
  - Lansing Field Office
  - Regional Office (Region 3)
  - Twin Cities

- Great Lakes Basin Commission

State
- Minnesota Department of Natural Resources
- Wisconsin Department of Natural Resources
- Michigan Department of Natural Resources

Table A2. Resource Persons Contacted as Part of Literature Search.

State Office

Illinois, Department of Natural Resources

Bill Anderson - research
Carl Becker - endangered species
Dennis Thornburg - waterfowl

Indiana, Department of Natural Resources

Bernard Buchow - Indiana Dunes
Bob Feldt - waterfowl

Michigan, Department of Natural Resources

Jerry Johnson - pilot
John Lerg - eagle program (winter)
Gerald Martz - waterfowl
Ed Milula - waterfowl

Minnesota, Department of Natural Resources

Carroll Henderson - nongame biologist
Bob Jessen - waterfowl

Wisconsin, Department of Natural Resources

Bob Dreis - Spooner district
Dick Hunt - Horicon district
Randle Jurewicz - endangered species
Jim Raber - Green Bay district
Tom Smith - Milwaukee district
John Wetzel - waterfowl
William Wheeler - pilot

Fish and Wildlife Service

Region 3

Charles Kjos
John Winship - pilot

Mike Avery - National Power Plant Team
Wayne Crayton - East Lansing area office, connecting channels
George Gard - Mid-winter survey compiler
Tim Kubiak - Green Bay area office
Len Shuman - East Lansing area office

Table A2 (concluded).

Audubon & Christmas Count Compilers

Martin Blagdurn - Anchor Bay, Lake St. Clair
R. G. Campbell - Sault Ste. Marie, Ontario
Bernard Chartier - Green Bay, WI
Mary Donald - Milwaukee, WI
Kim Eckart - Duluth, MN
Margaret Elliot - Muskegon, MI
Adrian Frietag - Sturgeon Bay, WI
Robert Grefe - Saginaw, MI
Michael Jorae - Traverse City, MI
Joseph Kleiman - Detroit, MI
Constance Limke - Marquette, MI
Robert Monman - Ludington, MI
Rose Marie Wismer - Port Huron, MI
Dick Verch - Ashland, WI

Miscellaneous

Ty Bauman - Bay Beach Park Wildlife Sanctuary, Green Bay
Noel Cutright - Wisconsin Electric Power Company, Milwaukee
Gary Dawson - Consumers Electric Power Company, Jackson, MI
David Evans - Researcher/bander, Hawk Ridge Nature Reserve, Duluth, MN
Janet Green - Amateur ornithologist, MN
Charles Kern - Northern Indiana Public Service
Tom Mcintz - Wisconsin Public Service, Green Bay
Dr. Richard Thorsell - Edison Electric Institute, Washington, DC
Dave Wilcox - Indiana Dunes National Lakeshore

University and College

Minnesota

Dr. P. B. Hofslund - Univ. of Minnesota, Duluth

Wisconsin

Tom Erdman - Univ. of Wisconsin, Green Bay
Dr. C. Weise - Univ. of Wisconsin, Milwaukee
Dr. R. Verch - Northland College, Ashland

Michigan

Dr. R. Drobney - Univ. of Michigan, Ann Arbor
Dr. W. Robinson - Northern Michigan University, Marquette
Dr. W. Scharf - Northwestern Michigan College, Traverse City

APPENDIX B. SUMMARY TABLES OF DOMINANT BIRDS RECORDED ON CHRISTMAS COUNTS AT SHORELINE SITES ALONG THE UPPER GREAT LAKES

Table B1. Summary of Selected Birds[a] Present on Christmas Counts - Grand Marais, Minnesota.

	5-year mean ± 1 S.D.				10-year mean ± 1 S.D.	
Families	1960 to 1964 (N=0)	1965 to 1969 (N=0)	1970 to 1974 (N=0)	1975 to 1979 (N=5)	1960 to 1969 (N=0)	1970 to 1979 (N=5)
Gaviidae						
Podicipedidae						
Anatidae				127.0 ± 21.9		127.0 ± 21.9
surface ducks				117.2 ± 24.5		117.2 ± 24.5
bay ducks				9.4 ± 2.9		9.4 ± 2.9
sea ducks						
mergansers						
Accipitridae				0.2 ± 0.5		0.2 ± 0.5
Laridae				186.0 ± 197.5		186.0 ± 197.5
Species						
Mallard						107.2 ± 22.3
Black duck						10.0 ± 6.1
Common goldeneye						7.6 ± 5.2
Bald eagle						0.2 ± 0.5
Herring gull						186.0 ± 197.5

[a]Includes dominant and/or unique species and family groups of those considered in present study.

Table B2. Summary of Selected Birds[a] Present on Christmas Counts - Duluth, Minnesota.

Families	5-year mean ± 1 S.D. 1960 to 1964 (N=5)	1965 to 1969 (N=5)	1970 to 1974 (N=5)	1975 to 1979 (N=5)	10-year mean ± 1 S.D. 1960 to 1969 (N=10)	1970 to 1979 (N=10)
Gaviidae						
Podicipedidae		0.2 ± 0.5	1.0 ± 1.2	0.4 ± 0.9	0.1 ± 0.3	0.7 ± 1.1
Anatidae	142.8 ± 113.0	45.4 ± 30.7	40.0 ± 24.4	63.8 ± 30.8	94.1 ± 93.4	51.9 ± 29.0
surface ducks	2.4 ± 2.2	2.2 ± 3.9	8.8 ± 11.2	14.8 ± 24.0	2.3 ± 3.0	11.8 ± 17.9
bay ducks	82.2 ± 45.8	32.0 ± 24.2	21.6 ± 12.3	28.4 ± 18.5	57.1 ± 43.5	25.0 ± 15.3
sea ducks	50.8 ± 112.5	6.4 ± 14.3	4.4 ± 5.6	10.2 ± 22.3	28.6 ± 79.1	7.3 ± 15.6
mergansers	7.4 ± 6.3	4.8 ± 5.8	5.2 ± 3.1	10.4 ± 6.9	6.1 ± 5.9	7.8 ± 5.8
Accipitridae			0.4 ± 0.9			0.2 ± 0.6
Laridae	341.4 ± 476.0	396.2 ± 307.9	435.0 ± 554.8	206.6 ± 65.9	368.8 ± 379.0	370.8 ± 410.7
Species						
Mallard					2.1 ± 3.1	11.6 ± 17.6
Common goldeneye					55.4 ± 42.5	24.0 ± 15.1
Oldsquaw					28.3 ± 78.5	7.0 ± 15.6
Bald eagle						0.2 ± 0.6
Herring gull					365.6 ± 374.0	368.2 ± 411.8
Ring-billed gull					1.2 ± 3.8	1.1 ± 3.5
Snowy owl					2.7 ± 2.3	4.0 ± 3.0

[a]Includes dominant and/or unique species and family groups of those considered in present study.

Table B3. Summary of Selected Birds[a] Present on Christmas Counts - Ashland, Wisconsin.

Families	5-year mean ± 1 S.D. 1960 to 1964 (N=0)	1965 to 1969 (N=0)	1970 to 1974 (N=0)	1975 to 1979 (N=2)	10-year mean ± 1 S.D. 1960 to 1969 (N=0)	1970 to 1979 (N=2)
Gaviidae						
Podicipedidae						
Anatidae				67.0 ± 49.5		67.0 ± 49.5
surface ducks				64.5 ± 46.0		64.5 ± 46.0
bay ducks				2.0 ± 2.8		2.0 ± 2.8
sea ducks						
mergansers				0.5 ± 0.7		0.5 ± 0.7
Accipitridae				0.5 ± 0.7		0.5 ± 0.7
Laridae				14.5 ± 13.4		14.5 ± 13.4
Species						
Mallard						29.5 ± 30.4
Black duck						35.0 ± 15.6
Bald eagle						0.5 ± 0.7
Herring gull						14.5 ± 13.4
Snowy owl						2.5 ± 2.1

[a]Includes dominant and/or unique species and family groups of those considered in present study.

Table B4. Summary of Selected Birds[a] Present on Christmas Counts - Marquette, Michigan.

Families	5-year mean ± 1 S.D. 1960 to 1964 (N=5)	1965 to 1969 (N=5)	1970 to 1974 (N=5)	1975 to 1979 (N=5)	10-year mean ± 1 S.D. 1960 to 1969 (N=10)	1970 to 1979 (N=10)
Gaviidae						
Podicipedidae		0.2 ± 0.5			0.1 ± 0.3	
Anatidae	47.4 ± 40.7	83.6 ± 13.0	53.2 ± 27.1	84.6 ± 47.1	65.5 ± 34.3	68.9 ± 39.8
surface ducks		5.4 ± 8.4	1.8 ± 1.1	3.8 ± 4.8	2.7 ± 6.3	2.8 ± 3.4
bay ducks	43.6 ± 40.6	66.2 ± 9.2	37.2 ± 18.8	71.6 ± 38.9	54.9 ± 30.2	54.4 ± 34.0
sea ducks		0.8 ± 0.8	6.0 ± 8.3	2.8 ± 5.7	0.4 ± 0.7	4.4 ± 7.0
mergansers	3.8 ± 3.1	10.2 ± 7.8	2.2 ± 1.8	5.6 ± 8.3	7.0 ± 6.6	3.9 ± 5.9
Accipitridae						
Laridae	556.0 ± 96.4	316.0 ± 265.6	446.6 ± 258.4	336.2 ± 328.0	436.0 ± 226.9	391.4 ± 284.4
Species						
Common goldeneye					52.7 ± 29.5	42.3 ± 32.9
Bufflehead					0.8 ± 1.5	7.7 ± 10.5
Herring gull					436.0 ± 226.9	238.5 ± 236.2
Snowy owl					0.5 ± 0.7	0.2 ± 0.4

[a] Includes dominant and/or unique species and fami'y groups of those considered in present study.

Table B5. Summary of Selected Birds[a] Present on Christmas Counts - Green Bay, Wisconsin.

Families	5-year mean ± 1 S.D. 1960 to 1964 (N=1)	1965 to 1969 (N=5)	1970 to 1974 (N=5)	1975 to 1979 (N=5)	10-year mean ± 1 S.D. 1960 to 1969 (N=6)	1970 to 1979 (N=10)
Gaviidae						
Podicipedidae			0.8 ± 0.8			0.4 ± 0.7
Anatidae	882.0 ± 0.0	973.2 ± 249.1	1794.6 ± 411.4	2670.0 ± 764.5	958.0 ± 225.9	2232.3 ± 740.2
surface ducks	550.0 ± 0.0	713.6 ± 208.1	1373.8 ± 413.4	2111.8 ± 627.5	686.3 ± 197.7	1742.8 ± 634.2
bay ducks	9.0 ± 0.0	55.6 ± 37.9	51.2 ± 49.8	42.4 ± 26.6	47.8 ± 38.9	46.8 ± 37.9
sea ducks		35.8 ± 37.2				
mergansers	12.0 ± 0.0		3.4 ± 4.5	116.0 ± 73.8	31.8 ± 26.2	59.7 ± 77.2
Accipitridae		0.2 ± 0.5	0.2 ± 0.5	0.2 ± 0.5	0.2 ± 0.4	0.2 ± 0.4
Laridae	25.0 ± 0.0	30.0 ± 28.7	30.2 ± 52.5	187.0 ± 207.2	29.2 ± 25.8	108.6 ± 164.7
Species						
Canada goose					183.3 ± 76.5	381.3 ± 171.1
Mallard					263.8 ± 51.4	1224.7 ± 664.9
Black duck					422.3 ± 207.9	516.4 ± 213.9
Common goldeneye					38.5 ± 35.6	40.5 ± 32.0
Common merganser					31.2 ± 25.2	58.7 ± 76.2
Bald eagle					0.2 ± 0.4	0.1 ± 0.3
Gyrfalcon						0.1 ± 0.3
Herring gull					26.5 ± 22.5	108.5 ± 164.7
Snowy owl					5.2 ± 3.3	3.9 ± 3.0

[a]Includes dominant and/or unique species and family groups of those considered in present study.

Table B6. Summary of Selected Birds[a] Present on Christmas Counts - Sheboygan, Wisconsin.

Families	5-year mean ± 1 S.D. 1960 to 1964 (N=0)	1965 to 1969 (N=0)	1970 to 1974 (N=1)	1975 to 1979 (N=5)	10-year mean ± 1 S.D. 1960 to 1969 (N=0)	1970 to 1979 (N=6)
Gaviidae			1.0 ± 0.0	0.2 ± 0.5		0.3 ± 0.5
Podicipedidae			1.0 ± 0.0			0.2 ± 0.4
Anatidae			60.0 ± 0.0	134.4 ± 16.3		122.0 ± 33.7
surface ducks			6.0 ± 0.0	2.8 ± 1.9		3.3 ± 2.2
bay ducks			24.0 ± 0.0	82.0 ± 42.8		72.3 ± 45.0
sea ducks			28.0 ± 0.0	45.8 ± 57.4		42.8 ± 51.8
mergansers			2.0 ± 0.0	2.4 ± 3.8		2.3 ± 3.4
Accipitridae						
Laridae			506.0 ± 0.0	183.0 ± 98.3		236.8 ± 158.5
Species						
Common goldeneye						42.0 ± 47.5
Oldsquaw						42.2 ± 52.2
Herring gull						200.8 ± 158.1
Ring-billed gull						35.0 ± 80.9
Snowy owl						0.8 ± 1.2

[a]Includes dominant and/or unique species and family groups of those considered in present study.

Table B7. Summary of Selected Birds[a] Present on Christmas Counts - Milwaukee, Wisconsin.

Families	5-year mean ± 1 S.D. 1960 to 1964 (N=5)	1965 to 1969 (N=5)	1970 to 1974 (N=5)	1975 to 1979 (N=5)	10-year mean ± 1 S.D. 1960 to 1969 (N=10)	1970 to 1979 (N=10)
Gaviidae	1.2 ± 1.6	0.8 ± 1.8	0.4 ± 0.9	0.8 ± 1.1	1.0 ± 1.6	0.6 ± 1.0
Podicipedidae		0.2 ± 0.5	0.2 ± 0.5		0.1 ± 0.3	0.1 ± 0.3
Anatidae	10,692.4 ± 6059.3	24,295.8 ± 5079.2	17,363.0 ± 10,628.7	7222.2 ± 3472.2	17,494.1 ± 8898.7	12,292.6 ± 9172.4
surface ducks	3071.6 ± 1390.6	4899.0 ± 2496.3	3296.4 ± 1657.4	3196.8 ± 1924.6	3985.3 ± 2134.6	3246.6 ± 1694.1
bay ducks	4603.8 ± 6450.8	9749.8 ± 4273.1	6395.4 ± 4243.6	2041.4 ± 1576.7	7176.8 ± 5828.0	4218.4 ± 3791.4
sea ducks	1503.8 ± 2015.4	9210.0 ± 5911.3	7628.2 ± 5245.9	1920.0 ± 2251.6	5356.9 ± 5816.5	4774.1 ± 4851.3
mergansers	172.0 ± 226.6	36.6 ± 22.9	39.8 ± 72.0	30.8 ± 30.3	104.3 ± 167.7	35.3 ± 52.3
Accipitridae						
Laridae	1278.0 ± 931.6	2918.2 ± 2638.0	2255.6 ± 3502.8	1647.0 ± 1822.7	2098.1 ± 2055.7	1951.3 ± 2651.9
Species						
Mallard					3601.3 ± 1978.2	2982.7 ± 1656.3
Black duck					379.8 ± 206.9	254.1 ± 195.7
Greater scaup					2837.2 ± 2877.7	1850.4 ± 1681.3
Lesser scaup					754.7 ± 2379.6	6.0 ± 17.6

Table B7 (concluded).

Families	5-year mean ± 1 S.D. 1960 to 1964 (N=5)	1965 to 1969 (N=5)	1970 to 1974 (N=5)	1975 to 1979 (N=5)	10-year mean ± 1 S.D. 1960 to 1969 (N=10)	1970 to 1979 (N=10)
Common goldeneye					3426.7 ± 3228.4	2271.6 ± 3105.6
Oldsquaw					5356.1 ± 5815.9	4773.6 ± 4851.1
Herring gull					1737.2 ± 2134.4	1510.3 ± 2481.1
Ring-billed gull					160.9 ± 143.8	359.6 ± 362.5
Snowy owl					0.7 ± 0.8	0.1 ± 0.3

[1] Includes dominant and/or unique species and family groups of those considered in present study.

Table B8. Summary of Selected Birds[a] Present on Christmas Counts - Hales Corners, Wisconsin.

Families	5-year mean ± 1 S.D. 1960 to 1964 (N=4)	1965 to 1969 (N=4)	1970 to 1974 (N=5)	1975 to 1979 (N=5)	10-year mean ± 1 S.D. 1960 to 1969 (N=8)	1970 to 1979 (N=10)
Gaviidae						
Podicipedidae	0.5 ± 0.6	0.3 ± 0.5	0.2 ± 0.5		0.4 ± 0.5	0.1 ± 0.3
Anatidae	3931.0 ± 3068.4	4761.5 ± 5348.8	4781.8 ± 4848.5	2332.2 ± 1345.4	4346.3 ± 4061.2	3557.0 ± 3594.7
surface ducks	198.3 ± 58.1	231.3 ± 111.6	269.6 ± 168.9	271.6 ± 281.9	214.8 ± 84.3	270.6 ± 219.1
bay ducks	3597.8 ± 3152.4	3304.3 ± 3030.3	3262.8 ± 4874.4	1298.8 ± 1012.0	3451.0 ± 2866.9	2280.8 ± 3476.6
sea ducks	104.8 ± 108.9	1192.5 ± 2260.6	1220.0 ± 1515.3	679.6 ± 390.0	648.6 ± 1591.6	949.8 ± 1081.3
mergansers	29.8 ± 38.1	28.5 ± 25.7	29.4 ± 20.7	76.2 ± 75.3	29.1 ± 30.1	52.8 ± 57.6
Accipitridae						
Laridae	3188.3 ± 2051.8	340.0 ± 129.2	361.0 ± 219.9	368.6 ± 249.0	1764.1 ± 2032.1	364.8 ± 221.5
Species						
Mallard					132.1 ± 73.9	234.0 ± 215.6
Black duck					82.3 ± 23.1	31.6 ± 20.1
Greater scaup					869.3 ± 1244.8	1205.3 ± 2293.1
Common goldeneye					2454.4 ± 2271.9	948.7 ± 1262.8
Oldsquaw					648.6 ± 1591.6	948.7 ± 1078.2
Herring gull					804.9 ± 868.7	297.3 ± 205.8
Ring-billed gull					959.1 ± 1384.2	59.4 ± 67.3

[a]Includes dominant and/or unique species and family groups of those considered in present study.

Table B9. Summary of Selected Birds[a] Present on Christmas Counts - Racine, Wisconsin.

Families	5-year mean ± 1 S.D. 1960 to 1964 (N=5)	1965 to 1969 (N=4)	1970 to 1974 (N=0)	1975 to 1979 (N=0)	10-year mean ± 1 S.D. 1960 to 1969 (N=9)	1970 to 1979 (N=0)
Gaviidae	0	0			0	
Podicipedidae	0	0			0	
Anatidae	3145.4 ± 1660.2	5029.0 ± 1604.0			3982.6 ± 1824.4	
surface ducks	1013.2 ± 593.8	1142.8 ± 312.8			1070.8 ± 466.5	
bay ducks	1279.4 ± 961.1	1277.0 ± 345.2			1278.3 ± 711.8	
sea ducks	729.4 ± 738.4	2281.3 ± 1360.8			1419.1 ± 1279.0	
mergansers	84.4 ± 79.3	184.0 ± 128.8			128.7 ± 110.1	
Accipitridae	0	0			0	
Laridae	846.8 ± 608.8	2041.5 ± 867.6			1377.8 ± 929.5	
Species						
Canada goose					85.1 ± 60.7	
Mallard					851.9 ± 380.9	
Black duck					217.0 ± 160.3	
Common goldeneye					1110.9 ± 638.3	
Bufflehead					131.1 ± 78.1	
Oldsquaw					1417.8 ± 1278.2	
Common merganser					91.9 ± 84.0	
Herring gull					1240.8 ± 856.9	
Bonaparte's gull					122.9 ± 350.6	
Snowy owl					0.8 ± 1.3	

[a] Includes unique and/or dominant species and family groups of those considered in present study

Table B10. Summary of Selected Birds[a] Present on Christmas Counts - Kenosha, Wisconsin.

Families	5-year mean ± 1 S.D. 1960 to 1964 (N=1)	1965 to 1969 (N=5)	1970 to 1974 (N=5)	1975 to 1979 (N=4)	10-year mean ± 1 S.D. 1960 to 1969 (N=6)	1970 to 1979 (N=9)
Gaviidae						
Podicipedidae						
Anatidae	1243.0 ± 0.0	247.4 ± 64.1	533.2 ± 484.0	802.0 ± 511.4	421.7 ± 406.4	652.7 ± 485.1
surface ducks	4.0 ± 0.0	15.2 ± 21.5	5.4 ± 6.6	113.8 ± 60.2	13.3 ± 19.8	53.6 ± 68.1
bay ducks	117.0 ± 0.0	82.8 ± 54.3	109.6 ± 63.2	485.5 ± 501.4	88.5 ± 50.5	276.7 ± 368.2
sea ducks	1081.0 ± 0.0	148.6 ± 14.3	409.4 ± 430.3	172.3 ± 213.8	304.0 ± 380.9	304.0 ± 354.0
mergansers	41.0 ± 0.0	9.2 ± 10.8	7.0 ± 8.4	24.5 ± 24.8	14.5 ± 16.2	14.8 ± 18.7
Accipitridae						
Laridae	235.0 ± 0.0	305.0 ± 271.3	2449.4 ± 1269.2	284.0 ± 248.8	293.3 ± 244.4	1487.0 ± 1458.9
Species						
Mallard					12.3 ± 19.5	52.2 ± 66.8
Common goldeneye					87.8 ± 50.6	264.7 ± 347.3
Oldsquaw					304.0 ± 380.9	303.2 ± 354.7
Common merganser					11.3 ± 12.9	8.1 ± 16.3
Herring gull					269.8 ± 240.0	1254.1 ± 1193.8
Ring-billed gull					20.3 ± 44.4	201.3 ± 439.3
Snowy owl					0.5 ± 0.8	0.2 ± 0.7

[a] Includes dominant and/or unique species and family groups of those considered in present study.

Table B11. Summary of Selected Birds[a] Present on Christmas Coun - Chicago Lakefront.

Families	5-year mean ± 1 S.D. 1960 to 1964 (N=5)	1965 to 1969 (N=5)	1970 to 1974 (N=5)	1975 to 1979 (N=4)	10-year mean ± 1 S.D. 1960 to 1969 (N=5)	1970 to 1979 (N=9)
Gaviidae				0.3 ± 0.5		0.1 ± 0.3
Podicipedidae		0.2 ± 0.5	0.2 ± 0.5		0.2 ± 0.5	0.1 ± 0.3
Anatidae		3276.4 ± 2886.5	2163.4 ± 3014.6	2196.8 ± 793.0	3276.4 ± 2886.5	2178.2 ± 2186.3
surface bay		212.8 ± 141.9	403.8 ± 132.7	938.8 ± 726.9	212.8 ± 141.9	641.9 ± 535.2
bay ducks		2272.2 ± 3135.4	1625.0 ± 2971.5	1039.8 ± 895.2	2272.2 ± 3135.4	1365.3 ± 2193.4
sea ducks		342.2 ± 290.8	93.0 ± 49.3	42.8 ± 43.8	342.2 ± 290.8	70.7 ± 51.4
mergansers		25.8 ± 12.0	40.2 ± 32.4	166.0 ± 202.8	25.8 ± 12.0	96.1 ± 142.6
Accipitridae						
Laridae		797.6 ± 996.6	1073.4 ± 879.1	708.8 ± 521.1	797.6 ± 996.6	911.3 ± 724.7
Species						
Mallard					202.3 ± 132.7	625.3 ± 538.8
Scaup species					1751.2	973.8
Common goldeneye					515.6 ± 227.6	385.4 ± 263.8
Oldsquaw					336.0 ± 277.6	70.2 ± 50.8
Common merganser					18.8 ± 14.3	60.0 ± 151.9
Herring gull					627.2 ± 816.2	332.8 ± 251.8
Ring-billed gull					142.6 ± 155.5	213.0 ± 313.0
Bonaparte's gull					20.8 ± 34.5	51.0 ± 121.0

[a] Includes dominant and/or unique species and family groups of those considered in present study.

Table B12. Summary of Selected Birds[a] Present on Christmas Counts - Chicago North Shore.

Families	5-year mean ± 1 S.D. 1960 to 1964 (N=2)	1965 to 1969 (N=5)	1970 to 1974 (N=5)	1975 to 1979 (N=5)	10-year mean ± 1 S.D. 1960 to 1969 (N=7)	1970 to 1979 (N=10)
Gaviidae						
Podicipedidae		0.4 ± 0.9	0.6 ± 0.6	0.6 ± 0.6	0.3 ± 0.8	0.6 ± 0.5
Anatidae	372.0 ± 4.2	1163.2 ± 680.9	2237.8 ± 404.1	3533.8 ± 1536.2	937.1 ± 676.8	2885.8 ± 1260.2
surface ducks	49.0 ± 28.3	202.2 ± 187.9	836.6 ± 289.0	1884.0 ± 395.0	158.4 ± 171.0	1360.3 ± 641.5
bay ducks	214.5 ± 30.4	491.2 ± 244.0	825.0 ± 278.7	705.6 ± 411.8	412.1 ± 241.0	756.3 ± 337.4
sea ducks	71.5 ± 26.2	446.6 ± 377.4	403.8 ± 224.5	155.8 ± 130.5	339.4 ± 358.5	279.8 ± 216.9
mergansers	37.0 ± 28.3	19.8 ± 19.6	22.6 ± 29.4	11.2 ± 6.9	24.7 ± 21.5	16.9 ± 21.0
Accipitridae			0.4 ± 0.6			0.2 ± 0.4
Laridae	763.0 ± 2.8	727.2 ± 366.4	914.8 ± 681.8	383.2 ± 251.1	737.4 ± 299.7	649.0 ± 559.6
Species						
Canada goose					2.4 ± 3.9	153.6 ± 145.2
Mallard					141.3 ± 159.0	1293.5 ± 638.6
Scaup species					35.8	50.2
Common goldeneye					372.7 ± 204.9	209.6 ± 373.6
Oldsquaw					335.7 ± 357.2	244.4 ± 175.5
Common merganser					16.4 ± 15.2	10.6 ± 21.4
Merlin						0.1 ± 0.3
Bald eagle						0.1 ± 0.3
Herring gull					685.7 ± 284.7	449.5 ± 368.4
Ring-billed gull					50.4 ± 36.2	49.3 ± 80.7
Bonaparte's gull					1.1 ± 2.2	51.2 ± 84.0
Snowy owl					0.4 ± 0.8	

[a]Includes dominant and/or unique species and family groups of those considered in present study.

Table B13. Summary of Selected Birds[a] Present on Christmas Counts - Indiana Dunes, Indiana.

Families	5-year mean ± 1 S.D. 1960 to 1964 (N=0)	1965 to 1969 (N=0)	1970 to 1974 (N=2)	1975 to 1979 (N=5)	10-year mean ± 1 S.D. 1960 to 1969 (N=0)	1970 to 1979 (N=7)
Gaviidae				0.6 ± 0.9		0.4 ± 0.8
Podicipedidae			1.5 ± 2.1	1.8 ± 2.2		1.7 ± 2.0
Anatidae			379.5 ± 77.1	1101.8 ± 509.2		895.4 ± 549.9
surface ducks			102.0 ± 91.9	440.4 ± 123.3		343.7 ± 197.0
bay ducks			248.5 ± 187.4	487.4 ± 370.8		419.1 ± 333.3
sea ducks				9.8 ± 12.7		7.0 ± 11.5
mergansers			9.5 ± 9.2	77.4 ± 33.9		58.0 ± 43.3
Accipitridae				0.4 ± 0.6		0.3 ± 0.5
Laridae			1694.5 ± 2129.1	807.0 ± 462.6		1060.6 ± 1042.0
Species						
Canada goose						64.5 ± 46.3
Mallard						310.6 ± 182.3
Black duck						27.3 ± 22.9
Common goldeneye						173.6 ± 167.0
Bufflehead						192.7 ± 148.2
Common merganser						28.7 ± 27.6
Red-breasted merganser						24.4 ± 31.4
Herring gull						627.0 ± 492.9
Ring-billed gull						391.1 ± 586.7
Merlin						0.3 ± 0.5

[a] Includes dominant and/or unique species and family groups of those considered in present study.

Table B14. Summary of Selected Birds[a] Present on Christmas Counts - Calumet, Illinois.

Families	5-year mean ± 1 S.D. 1960 to 1964 (N=0)	1965 to 1969 (N=3)	1970 to 1974 (N=5)	1975 to 1979 (N=5)	10-year mean ± 1 S.D. 1960 to 1969 (N=3)	1970 to 1979 (N=10)
Gaviidae				0.2 ± 0.5		0.1 ± 0.3
Podicipedidae			0.4 ± 0.6	1.4 ± 1.2		0.9 ± 1.5
Anatidae		808.0 ± 1169.2	1394.6 ± 1881.0	1389.8 ± 963.4	808.0 ± 1169.2	1392.2 ± 1408.9
surface ducks		121.7 ± 3.1	178.2 ± 94.2	684.0 ± 223.9	121.7 ± 3.1	431.1 ± 311.9
bay ducks		685.3 ± 1171.5	1177.4 ± 1796.0	337.0 ± 384.0	685.3 ± 1171.5	757.2 ± 1302.1
sea ducks		0.3 ± 0.6	0.2 ± 0.5	0.8 ± 1.8	0.3 ± 0.6	0.5 ± 1.3
mergansers			8.8 ± 12.3	131.6 ± 152.0		70.2 ± 120.5
Accipitridae						
Laridae		4238.3 ± 3444.3	1272.4 ± 999.5	3331.6 ± 2065.0	4238.3 ± 3444.3	2302.0 ± 1875.4
Species						
Mallard					120.0 ± 1.0	422.6 ± 308.0
Scaup spp.					666.7 ± 1154.7	613.0
Common goldeneye					18.7 ± 19.0	141.7 ± 173.3
Herring gull					4237.3 ± 3443.3	1994.6 ± 1487.9
Ring-billed gull					1.0 ± 1.7	196.1 ± 278.5
Snowy owl					1.3 ± 2.3	

[a] Includes dominant and/or unique species and family groups of those considered in present study.

Table B15. Summary of Selected Birds[a] Present on Christmas Counts - Michigan City, Indiana.

Families	5-year mean ± 1 S.D.				10-year mean ± 1 S.D.	
	1960 to 1964 (N=4)	1965 to 1969 (N=2)	1970 to 1974 (N=0)	1975 to 1979 (N=0)	1960 to 1969 (N=6)	1970 to 1979 (N=0)
Gaviidae						
Podicipedidae	1.5 ± 1.7		1.0 ± 1.6		1.0 ± 1.5	
Anatidae	676.5 ± 277.0	709.0 ± 79.2	687.3 ± 218.1		687.3 ± 218.1	
surface ducks	229.8 ± 128.6	370.5 ± 37.5	276.7 ± 124.4		276.7 ± 124.4	
bay ducks	320.8 ± 132.9	315.5 ± 24.8	319.0 ± 103.5		319.0 ± 103.5	
sea ducks	15.3 ± 11.8	11.5 ± 12.0	14.0 ± 10.8		14.0 ± 10.8	
mergansers	109.3 ± 99.2	8.0 ± 0.0	75.5 ± 93.0		75.5 ± 93.0	
Accipitridae						
Laridae	316.0 ± 297.7	1195.0 ± 855.6	609.0 ± 632.0		609.0 ± 632.0	
Species						
Mallard					132.5 ± 74.3	
Black duck					138.0 ± 68.6	
Common goldeneye					103.0 ± 60.7	
Common merganser					64.7 ± 75.6	
Herring gull					446.7 ± 434.8	
Ring-billed gull					162.3 ± 217.7	
Snowy owl					0.5 ± 0.6	

[a]Includes dominant and/or unique species and family groups of those considered in present study.

Table B16. Summary of Selected Birds[a] Present on Christmas Counts - Muskegon, Michigan.

Families	5-year mean ± 1 S.D. 1960 to 1964 (N=5)	1965 to 1969 (N=5)	1970 to 1974 (N=5)	1975 to 1979 (N=5)	10-year mean ± 1 S.D. 1960 to 1969 (N=10)	1970 to 1979 (N=10)
Gaviidae	0.2 ± 0.5	0.2 ± 0.5			0.2 ± 0.4	
Podicipedidae	0.2 ± 0.5	0.6 ± 1.3	2.2 ± 2.4	2.8 ± 3.5	0.4 ± 1.0	2.5 ± 2.8
Anatidae	1400.0 ± 451.5	1041.2 ± 461.0	628.2 ± 270.2	3879.4 ± 4696.4	1220.6 ± 469.9	2753.8 ± 3573.7
surface ducks	244.0 ± 279.8	207.6 ± 144.3	163.0 ± 175.8	86.4 ± 67.2	225.8 ± 210.7	124.7 ± 131.8
bay ducks	823.8 ± 597.7	327.2 ± 144.1	301.6 ± 78.0	297.4 ± 184.2	575.5 ± 486.3	300.0 ± 133.4
sea ducks	1.2 ± 1.1	12.8 ± 23.1	0.4 ± 0.9		7.0 ± 16.6	0.2 ± 0.6
mergansers	325.8 ± 395.6	454.6 ± 359.1	150.6 ± 112.2	3463.2 ± 4635.9	390.2 ± 362.6	1806.9 ± 3550.4
Accipitridae						
Laridae	1483.0 ± 723.4	710.4 ± 310.9	2338.0 ± 4426.8	571.6 ± 877.3	1096.7 ± 664.3	1454.8 ± 3149.4
Species						
Whistling swan					12.7 ± 21.6	43.2 ± 47.1
Mallard					12.3 ± 13.6	47.5 ± 38.7
Black duck					104.3 ± 171.0	23.0 ± 23.7
Gadwall					36.2 ± 53.9	53.3 ± 114.1
Scaup spp.					201.2 ±	39.2 ±
Common goldeneye					334.1 ± 487.4	192.2 ± 121.9
Common merganser					388.0 ± 361.8	
Herring gull					1095.0 ± 664.8	1424.3 ± 3073.6
Ring-billed gull					1.4 ± 1.8	26.6 ± 78.8
Snowy owl					2.0 ± 1.6	1.7 ± 1.6

[a] Includes dominant and/or unique species and family groups of those considered in present study.

Table B17. Summary of Selected Birds[a] Present on Christmas Counts - Ludington, Michigan.

Families	5-year mean ± 1 S.D. 1960 to 1964 (N=0)	1965 to 1969 (N=2)	1970 to 1974 (N=4)	1975 to 1979 (N=5)	10-year mean ± 1 S.D. 1960 to 1969 (N=2)	1970 to 1979 (N=9)
Gaviidae						
Podicipedidae			0.3 ± 0.5			0.1 ± 0.3
Anatidae		361.5 ± 120.9	343.0 ± 129.2	268.2 ± 170.9	361.5 ± 120.9	301.4 ± 149.8
surface ducks		80.5 ± 85.6	67.3 ± 36.1	54.6 ± 25.1	80.5 ± 85.6	60.2 ± 29.1
bay ducks		122.5 ± 50.2	101.8 ± 56.5	95.6 ± 38.1	122.5 ± 50.2	98.3 ± 44.0
sea ducks						
mergansers		5.0 ± 7.1	4.8 ± 4.6	8.6 ± 10.9	5.0 ± 7.1	6.9 ± 8.5
Accipitridae						
Laridae		193.0 ± 230.5	606.5 ± 364.3	253.6 ± 216.3	193.0 ± 230.5	410.4 ± 328.3
Species						
Canada goose					142.0 ± 94.8	127.9 ± 96.6
Black duck					66.0 ± 65.1	44.7 ± 24.3
Common goldeneye					55.5 ± 54.5	66.6 ± 36.1
Bufflehead					64.5 ± 7.8	30.1 ± 18.1
Herring gull					863.0 ± 371.9	410.4 ± 328.3
Ring-billed gull					100.0 ± 141.4	
Bald eagle						0.1 ± 0.3
Snowy owl						0.7 ± 0.7

[a] Includes dominant and/or unique species and family groups of those considered in present study.

Table B18. Summary of Selected Birds[a] Present on Christmas Counts - Traverse City, Michigan.

Families	5-year mean ± 1 S.D. 1960 to 1964 (N=5)	1965 to 1969 (N=5)	1970 to 1974 (N=5)	1975 to 1979 (N=5)	10-year mean ± 1 S.D. 1960 to 1969 (N=10)	1970 to 1979 (N=10)
Gaviidae	0.2 ± 0.5	0.8 ± 1.8	2.2 ± 2.3	1.0 ± 1.4	0.5 ± 1.3	1.6 ± 1.9
Podicipedidae	3.4 ± 3.6	5.8 ± 3.8	23.0 ± 30.4	13.4 ± 16.4	4.6 ± 3.7	18.2 ± 23.6
Anatidae	577.0 ± 279.2	748.2 ± 281.2	1371.4 ± 279.4	1941.6 ± 532.1	662.6 ± 279.1	1656.5 ± 500.8
surface ducks	70.2 ± 67.8	160.0 ± 36.0	459.6 ± 199.6	1170.8 ± 262.4	115.1 ± 69.7	815.2 ± 434.5
bay ducks	356.6 ± 195.9	399.0 ± 188.4	402.4 ± 71.9	387.2 ± 200.2	377.8 ± 182.6	394.8 ± 142.0
sea ducks	0.8 ± 1.8	2.2 ± 3.9	1.6 ± 3.1	2.0 ± 4.5	1.5 ± 3.0	1.8 ± 3.6
mergansers	20.0 ± 7.8	17.2 ± 19.6	118.4 ± 117.3	52.0 ± 24.4	18.6 ± 14.1	85.2 ± 87.2
Accipitridae	0.2 ± 0.5	0.2 ± 0.5			0.2 ± 0.4	
Laridae	432.6 ± 412.4	192.4 ± 180.6	766.8 ± 431.7	774.6 ± 1105.2	312.5 ± 325.8	770.7 ± 791.0
Species						
Mute swan					148.7 ± 49.4	344.5 ± 107.0
Horned grebe					4.3 ± 4.0	17.7 ± 23.6
Mallard					41.6 ± 34.7	646.6 ± 421.2
Black duck					23.3 ± 41.8	167.4 ± 82.6
Scaup spp.					146.5 ± 84.7	160.5
Common goldeneye					166.6 ± 84.1	167.7 ± 53.9
Bufflehead					64.3 ± 28.5	65.4 ± 23.2
Common merganser					14.1 ± 10.0	79.9 ± 86.0
Bald eagle					0.2 ± 0.4	
Herring gull					269.6 ± 320.4	284.8 ± 453.3
Ring-billed gull					42.9 ± 67.0	485.8 ± 364.9
Snowy owl					1.0 ± 1.3	0.6 ± 0.8

[a] Includes dominant and/or unique species and family groups of those considered in present study.

Table B19. Summary of Selected Birds[a] Present on Christmas Counts - Alpena, Michigan.

Families	5-year mean ± 1 S.D. 1960 to 1964 (N=0)	1965 to 1969 (N=4)	1970 to 1974 (N=5)	1975 to 1979 (N=5)	10-year mean ± 1 S.D. 1960 to 1969 (N=4)	1970 to 1979 (N=10)
Gaviidae						
Podicipedidae			0.4 ± 0.9			0.2 ± 0.6
Anatidae		242.5 ± 27.6	486.2 ± 197.3	874.6 ± 331.1	242.5 ± 27.6	680.4 ± 328.5
surface ducks		102.0 ± 24.6	252.0 ± 158.6	539.2 ± 253.7	102.2 ± 24.6	395.6 ± 250.4
bay ducks		72.0 ± 55.6	81.6 ± 39.8	75.2 ± 44.3	72.0 ± 55.6	78.4 ± 39.8
sea ducks		2.5 ± 3.0	0.4 ± 0.9	6.0 ± 8.5	2.5 ± 3.0	3.2 ± 6.4
mergansers		43.8 ± 27.5	60.0 ± 46.9	20.2 ± 19.9	43.8 ± 27.5	40.1 ± 39.9
Accipitridae		0.8 ± 1.0		0.2 ± 0.5	0.8 ± 1.0	0.1 ± 0.3
Laridae		79.0 ± 73.1	172.6 ± 203.1	172.4 ± 251.4	79.0 ± 75.1	172.5 ± 215.4
Species						
Canada goose					15.8 ± 26.2	156.4 ± 106.8
Mallard					101.8 ± 24.3	365.6 ± 232.7
Common goldeneye					65.8 ± 54.4	76.4 ± 40.3
Common merganser					43.3 ± 27.7	39.4 ± 40.1
Bald eagle					0.8 ± 1.0	0.1 ± 0.3
Herring gull					77.5 ± 75.0	168.3 ± 208.0
Snowy owl						0.3 ± 0.5

[a]Includes dominant and/or unique species and family groups of those considered in present study.

Table B20. Summary of Selected Birds[a] Present on Christmas Counts - Bay City, Michigan.

	5-year mean ± 1 S.D.				10-year mean ± 1 S.D.	
Families	1960 to 1964 (N=5)	1965 to 1969 (N=5)	1970 to 1974 (N=5)	1975 to 1979 (N=5)	1960 to 1969 (N=10)	1970 to 1979 (N=10)
Gaviidae						
Podicipedidae	0.2 ± 0.5	0.6 ± 1.3	1.4 ± 2.1	3.6 ± 2.6	0.4 ± 1.0	2.5 ± 2.5
Anatidae	478.8 ± 542.9	499.0 ± 571.7	498.4 ± 68.5	2315.0 ± 2396.7	488.9 ± 525.7	1406.7 ± 1863.3
surface bay	152.0 ± 194.5	123.6 ± 167.8	133.0 ± 106.9	77.0 ± 84.2	137.8 ± 171.9	105.0 ± 95.4
bay ducks	14.2 ± 23.5	8.2 ± 12.6	8.4 ± 6.2	68.6 ± 98.7	11.2 ± 18.1	38.5 ± 73.2
sea ducks						
mergansers	312.4 ± 349.8	367.2 ± 554.8	356.6 ± 115.4	2166.8 ± 2362.9	339.8 ± 438.2	1261.7 ± 1843.3
Accipitridae	0.2 ± 0.5	0.2 ± 1.5			0.2 ± 0.4	
Laridae	87.4 64.7	203.2 ± 135.2	323.6 ± 229.1	1508.4 ± 953.8	145.3 ± 117.1	916.0 ± 904.2
Species						
Mallard					36.2 ± 96.0	62.0 ± 62.7
Black duck					101.5 ± 139.9	42.3 ± 44.1
Common goldeneye					11.0 ± 18.1	25.6 ± 48.0
Common merganser					301.2 ± 356.4	1029.7 ±1835.8
Red-breasted merganser					38.6 ± 109.7	231.3 ± 368.2
Bald eagle					0.2 ± 0.4	
Herring gull					114.4 ± 125.0	465.0 ± 912.9
Ring-billed gull					30.9 ± 35.6	450.5 ± 582.7
Snowy owl					1.1 ± 1.2	

[a]Includes dominant and/or unique species and family groups of those considered in present study.

Table B21. Summary of Selected Birds[a] Present on Christmas Counts - Detroit River.

	5-year mean ± 1 S.D.				10-year mean ± 1 S.D.	
Families	1960 to 1964 (N=0)	1965 to 1969 (N=0)	1970 to 1974 (N=0)	1975 to 1979 (N=2)	1960 to 1969 (N=0)	1970 to 1979 (N=2)
Gaviidae				0		0
Podicipedidae				0		0
Anatidae				1368.0 ± 333.8		1368.0 ± 33.8
surface ducks				756.5 ± 23.3		756.5 ± 23.3
bay ducks				520.5 ± 249.6		520.5 ± 249.6
sea ducks				0		0
mergansers				91.0 ± 107.5		91.0 ± 107.5
Accipitridae				0		0
Laridae				587.5 ± 416.5		587.5 ± 416.5
Species						
Mallard						668.0 ± 1.4
Black duck						75.5 ± 20.5
Canvasback						152.0 ± 152.7
Scaup spp.						176.0
Common goldeneye						127.5 ± 67.2
Snowy owl						0.5 ± 0.7
Herring gull						282.0 ± 59.4
Ring-billed gull						95.0 ± 134.4

[a]Includes dominant and/or unique species and family groups of those considered in present study.

Table B22. Summary of Selected Birds[a] Present on Christmas Counts - Anchor Bay, Michigan.

Families	5-year mean ± 1 S.D. 1960 to 1964 (N=0)	1965 to 1969 (N=1)	1970 to 1974 (N=0)	1975 to 1979 (N=2)	10-year mean ± 1 S.D. 1960 to 1969 (N=1)	1970 to 1979 (N=2)
Gaviidae		0		1.5 ± 2.1	0	1.5 ± 2.1
Podicipedidae		0		0	0	0
Anatidae		256.0 ± 0.0		9551.0 ± 4416.0	256.0 ± 0.0	9551.0 ± 4416.0
surface ducks		6.0 ± 0.0		644.0 ± 155.6	6.0 ± 0.0	644.0 ± 155.6
bay ducks		204.0 ± 0.0		8234.5 ± 4357.9	204.0 ± 0.0	8234.5 ± 4357.9
sea ducks		0		15.0 ± 21.2	0	15.0 ± 21.2
mergansers		19.0 ± 0.0		595.5 ± 47.4	19.0 ± 0.0	595.5 ± 47.4
Accipitridae		0		1.0 ± 0.0	0	1.0 ± 0.0
Laridae		94.0 ± 0.0		846.5 ± 84.2	94.0 ± 0.0	846.5 ± 84.2
Species						
Whistling Swan					27.0 ± 0.0	29.0 ± 15.6
Mallard					0	443.5 ± 65.7
Black duck					0	144.5 ± 128.0
Canvasback					116.0 ± 0.0	6960.5 ± 5089.1
Scaup spp.					61.0 ± 0.0	282.5 ± 171.8
Redhead					13.0 ± 0.0	614.0 ± 842.9
Common goldeneye					5.0 ± 0.0	331.5 ± 55.9
Common merganser					19.0 ± 0.0	583.5 ± 46.0
Bald eagle					0	0.5 ± 0.7
Peregrine falcon					0	0.5 ± 0.7
Thayer's gull					91.0 ± 0.0	0
Herring gull					1.0 ± 0.0	655.0 ± 1.4
Ring-billed gull					2.0 ± 0.0	167.0 ± 50.9
Snowy owl					1.0 ± 0.0	0

[a]Includes unique and/or dominant species and family groups of those considered in present study.

Table B23. Summary of Selected Birds[a] Present on Christmas Counts - Port Huron, Michigan.

Families	5-year mean ± 1 S.D. 1960 to 1964 (N=0)	1965 to 1969 (N=3)	1970 to 1974 (N=5)	1975 to 1979 (N=5)	10-year mean ± 1 S.D. 1960 to 1969 (N=3)	1970 to 1979 (N=10)
Gaviidae		0	0	0.2 ± 0.5	0	0.1 ± 0.3
Podicipedidae		0.3 ± 0.6	0.4 ± 0.6	0.8 ± 1.3	0.3 ± 0.6	0.6 ± 1.0
Anatidae		587.3 ± 376.4	2586.2 ± 3023.2	4317.8 ± 1836.8	587.3 ± 376.4	3452.0 ± 2528.7
surface ducks		25.3 ± 20.0	42.6 ± 46.2	345.2 ± 174.5	25.3 ± 20.0	193.9 ± 199.8
bay ducks		372.3 ± 317.1	892.6 ± 599.5	2951.4 ± 1535.8	372.3 ± 317.1	1922.0 ± 1544.5
sea ducks		38.0 ± 22.1	57.6 ± 24.5	56.0 ± 31.0	38.0 ± 22.1	56.8 ± 26.3
mergansers		151.7 ± 69.9	1590.2 ± 2867.2	950.4 ± 1130.3	151.7 ± 69.9	1270.3 ± 2082.1
Accipitridae		0.3 ± 0.6	0.2 ± 0.5	0.2 ± 0.5	0.3 ± 0.6	0.2 ± 0.4
Laridae		775.7 ± 523.7	5376.8 ± 5672.9	2054.4 ± 1511.5	775.7 ± 523.7	3715.6 ± 4287.7
Species						
Mallard					8.0 ± 6.6	162.3 ± 176.9
Black duck					14.3 ± 15.4	30.7 ± 25.9
Redhead					69.3 ± 119.2	404.7 ± 529.2
Canvasback					131.7 ± 141.0	979.7 ± 918.8
Common goldeneye					152.3 ± 70.5	431.9 ± 248.1
Oldsquaw					37.0 ± 21.2	51.9 ± 23.9
Common merganser					65.3 ± 13.3	505.0 ± 634.1
Red-breasted merganser					86.3 ± 56.6	763.8 ± 1664.1
Gry-falcon					0.3 ± 0.6	0
Bald eagle					0	0.1 ± 0.3
Peregrine falcon					0	0.1 ± 0.3
Herring gull					1095.0 ± 664.8	3532.5 ± 4197.5
Ring-billed gull					21.3 ± 18.5	170.6 ± 204.9
Snowy owl					0.7 ± 0.6	0.8 ± 1.0

[a] Includes unique and/or dominant species and family groups of those considered in present study.

Table B24. Summary of Selected Birds[a] Present on Christmas Counts - Monroe, Michigan.

Families	5-year mean ± 1 S.D. 1960 to 1964 (N=0)	1965 to 1969 (N=0)	1970 to 1974 (N=4)	1975 to 1979 (N=5)	10-year mean ± 1 S.D. 1960 to 1969 (N=0)	1970 to 1979 (N=9)
Gaviidae			0	0.2 ± 0.5		0.1 ± 0.3
Podicipedidae			2.5 ± 2.7	1.6 ± 3.6		2.0 ± 3.0
Anatidae			4971.3 ± 3944.0	3456.8 ± 4745.1		4129.9 ± 4210.5
surface ducks			2288.8 ± 2709.0	1151.0 ± 1810.7		1656.7 ± 2179.7
bay ducks			296.8 ± 215.7	151.8 ± 145.1		216.2 ± 183.9
sea ducks			0.3 ± 0.5	3.6 ± 8.1		2.1 ± 6.0
mergansers			2354.3 ± 2090.3	2123.0 ± 4299.4		2225.8 ± 3300.9
Accipitridae			0	0.2 ± 0.5		0.1 ± 0.3
Laridae			6958.3 ± 7486.4	6023.0 ± 3450.4		6438.7 ± 5216.6
Species						
Great blue heron						43.2 ± 47.1
Mallard						1226.8 ± 1751.9
Gadwall						411.7 ± 467.8
Common goldeneye						191.0 ± 178.7
Bald eagle						0.1 ± 0.3
Herring gull						4653.9 ± 3760.0
Ring-billed gull						1310.6 ± 1068.4
Bonaparte's gull						309.1 ± 704.5
Great black-backed gull						163.8 ± 143.8
Snowy owl						0.2 ± 0.4

[a] Includes unique and/or dominant species and family groups of those considered in present study

Table B25. Summary of Selected Birds[a] Present on Christmas Counts - Wauhegan, Wisconsin.

Families	5-year mean ± 1 S.D. 1960 to 1964 (N=5)	1965 to 1969 (N=4)	1970 to 1974 (N=5)	1975 to 1979 (N=5)	10-year mean ± 1 S.D. 1960 to 1969 (N=9)	1970 to 1979 (N=10)
Gaviidae	0	0	0	0	0	0
Podicipedidae	0.4 ± 0.6	0	0.4 ± 0.6	0	0.2 ± 0.4	0.2 ± 0.4
Anatidae	804.8 ± 521.0	812.8 ± 200.0	1360.6 ± 618.4	1963.0 ± 546.4	808.3 ± 388.2	1661.8 ± 635.2
surface ducks	21.8 ± 8.8	62.3 ± 36.9	243.8 ± 74.6	773.2 ± 391.4	39.7 ± 31.7	508.5 ± 385.2
bay ducks	462.8 ± 145.6	557.8 ± 226.8	747.2 ± 282.8	1024.8 ± 286.9	505.0 ± 180.0	886.0 ± 305.9
sea ducks	259.4 ± 418.1	184.8 ± 176.2	232.6 ± 416.0	114.0 ± 160.6	226.2 ± 317.2	173.3 ± 303.8
mergansers	60.4 ± 48.2	7.5 ± 9.9	11.6 ± 10.1	33.2 ± 11.6	36.9 ± 44.5	22.4 ± 15.3
Accipitridae	0	0	0	0	0	0
Laridae	265.2 ± 149.3	325.0 ± 342.5	498.2 ± 401.4	510.2 ± 459.9	291.8 ± 236.9	504.2 ± 407.0
Species						
Mallard					34.0 ± 31.2	474.0 ± 371.4
Scaup spp.					101.9 ±	301.1 ±
Common goldeneye					367.8 ± 170.9	525.6 ± 217.8
Oldsquaw					226.1 ± 317.3	169.1 ± 304.6
Common merganser					22.1 ± 26.5	15.1 ± 13.8
Herring gull					209.9 ± 171.0	242.0 ± 254.9
Ring-billed gull					70.2 ± 105.7	128.5 ± 154.3
Snowy owl					0.1 ± 0.3	0

[a] Includes unique and/or dominant species and family groups of those considered in present study

Table B26. Summary of Selected Birds[a] Present on Christmas Counts - Rogers City, Michigan.

Families	5-year mean ± 1 S.D. 1960 to 1964 (N=0)	1965 to 1969 (N=0)	1970 to 1974 (N=2)	1975 to 1979 (N=5)	10-year mean ± 1 S.D. 1960 to 1969 (N=0)	1970 to 1979 (N=7)
Gaviidae			0	0		0
Podicipedidae			0	0.6 ± 0.9		0.4 ± 0.8
Anatidae			159.0 ± 79.2	141.8 ± 91.6		146.7 ± 81.9
surface ducks			0	9.6 ± 7.0		6.9 ± 7.4
bay ducks			52.5 ± 37.5	92.2 ± 58.2		80.9 ± 53.6
sea ducks			0	8.4 ± 8.2		6.0 ± 7.8
mergansers			106.5 ± 41.7	31.6 ± 36.6		53.0 ± 50.2
Accipitridae			0.5 ± 0.7	0		0.1 ± 0.4
Laridae			392.5 ± 382.5	329.8 ± 289.8		347.7 ± 285.2
Species						
Common goldeneye						78.9 ± 51.9
Red-breasted merganser						42.4 ± 49.5
Bald eagle						0.1 ± 0.4
Herring gull						343.9 ± 285.5
Snowy owl						0.3 ± 0.5

[a]Includes unique and/or dominant species and family groups of those considered in present study Table

APPENDIX C. SUMMARY TABLES OF AERIAL WATERFOWL CENSUSES, 1980 and 1981

Table C1. Results of Aerial Waterfowl Censuses, 1980.

Date	Species[a] C	R	G	S	Bf	M	Bl	Gd	Wg	Anas	CM	Swan	Can G.	Other	TOTAL
1/8	22800	870	430	6470	35	640	170	10	10	---	---	---	---	---	31400
1/14	11200	1360	500	950	35	730	80	15	1	---	2	184	23	4	15100
1/15	7600	850	400	900	25	310	60	1	10	210	10	---	30	205	10700
1/21	780	4030	100	540	40	85	---	25	5	30	15	15	80	2	5800
1/22	800	3150	450	750	35	400	90	10	5	---	20	118	80	3	5800
1/28	9200	1700	1400	1365	10	900	90	5	5	30	55	---	340	3	23900
1/29	6450	1900	1100	1970	24	400	100	15	8	280	7	---	220	3	12500
2/4	9175	1130	1115	930	30	635	---	2	6	100	180	---	580	5	14000
2/5	10250	2020	2070	1420	26	415	155	4	15	645	395	112	---	11	16200
2/11	4220	1962	1483	872	7	1300	105	5	6	160	142	7	45	6	10300
2/12	3950	2100	2375	1520	18	1250	118	6	7	134	--	---	51	1	11500
2/18	7100	3360	1360	1370	35	389	78	3	6	95	70	92	268	3	14200
2/19	7300	2505	2277	1367	10	537	115	1	1	230	158	39	124	1	14700
2/25	3390	1410	560	570	24	120	60	2	4	170	100	2	50	---	6500
3/4	6060	1290	2140	570	7	400	115	--	4	---	90	115	55	42	10900
3/10	2780	1590	245	540	8	720	90	--	2	75	155	133	110	10	6500
3/11	2425	785	350	725	18	340	28	--	3	155	390	2	41	90	5400
3/19	675	640	280	335	15	390	70	3	10	---	285	168	---	133	3000
3/25	920	2250	304	1025	40	64	21	32	65	---	232	27	2	45	5100
3/26	1035	1450	340	1385	46	75	56	23	51	---	220	7	2	420	5200

[a]Species codes:

C	=	Canvasback	Wg	=	Wigeon
R	=	Redhead	Anas	=	Anas sp. (unable to further identify), Aythya = Aythya sp. (unable to further identify)
G	=	Common Goldeneye			
S	=	Lesser, Greater Scaup	CM	=	Common Merganser
Bf	=	Buffle Head	Swan	=	Mute and Whistling Swans
M	=	Mallard	Can G.	=	Canada Goose
Bl	=	Black Duck	Other	=	All other species
Gd	=	Gadwall	Total	=	Total ducks seen in that day

Table C2. Results of Aerial Waterfowl Censuses, 1981.

Date	Species[a]													TOTAL
	C	R	G	S	Aythya	Bf	M	Bl	Gd	Wg	CM	Swan	Can G.	Other	
1/10	5430	20	1455	190	----	20	732	10	1	3	4	--	---	25	7945
1/11	725	620	685	70	2280	2	555	75	--	2	---	--	---	3	4940
1/17	930	786	580	277	3200	15	205	--	--	2	13	--	---	6	6020
1/23	1790	1690	710	525	1440	20	330	30	--	--	444	18	17	12	5590
1/24	260	334	580	303	260	45	402	12	--	--	78	54	40	10	2375
1/30	351	412	758	610	2240	14	816	--	--	--	968	35	336	--	6540
2/7	1151	1286	896	416	----	23	432	--	--	2	701	23	321	5	5256
2/8	580	796	953	250	----	46	345	90	--	2	727	--	300	7	4096
2/13	1322	1025	835	320	1400	21	880	205	--	2	1100	9	106	9	7234
2/14	1602	951	1659	455	2500	80	1040	--	--	1	975	29	---	2	9512
2/22	10	14	295	24	----	--	545	--	--	--	830	5	26	3	1752
3/1	50	---	402	46	1160	15	345	--	--	--	982	--	45	--	2945
3/8	20	14	226	37	1410	19	342	26	--	--	608	3	45	--	2760
3/13	240	357	92	57	250	4	472	25	--	1	656	11	26	3	1794
3/22	28	51	132	828	300	26	395	25	--	30	758	--	27	--	2600
3/27	25	25	65	1663	----	15	255	20	--	--	284	--	25	2	2314

[a]For species codes, See Table Cl.

APPENDIX D. INFLUENCE OF TEMPERATURE AND TIME ON WATERFOWL FEEDING IN THE DETROIT RIVER

Table D1. Effect of Temperature on Frequency of Goldeneye Behaviors, January-March 1981[a].

		% feeding		
Temperature[b]	N[a]	Male	Female	Combined
-15 to -10	7	49	50	49
-10 to - 5	5	45	44	44[c]
- 5 to 0	14	47	53	50
0 to 5	11	52	59	56[c]
5 to 10	3	43	52	47

[a]Analyzed by 1/2 h periods.
[b]In °C.
[c]Significant differences ($p \leq 0.05$) between these two temperatures only (ANOVA).

Table D2. Effect of Temperature on Frequency of Scaup Behaviors, January-March 1981[a]

Temperature[b]	N[a]	% feeding[c] Male	Female	Combined
-15 to -10	4	25	35	29
-10 to - 5	4	33	38	34
- 5 to 0	12	42	43	42
0 to 5	14	39	44	41
5 to 10	3	30	31	32

[a]Analyzed by 1/2 h periods.
[b]In °C.
[c]No significant differences when tested by ANOVA.

Table D3. Effect of Time of Day on Frequency of Goldeneye Behaviors, Jan-Feb 1981.

Time	N[a]	% feeding Male	Female	Combined
0500 - 0900	7	59	61	60[b]
0900 - 1200	12	49	52	50
1200 - 1500	4	46	53	50
1500 - 1800	16	44	49	46[b]

[a] Number of 1/2 h periods.
[b] Both males and females significantly different (ANOVA) at $p \leq 0.05$ level.

Table D4. Effect of Time of Day on Frequency of Scaup Behaviors, Jan-Feb 1981.

Time	N[a]	% feeding[b] Male	Female	Combined
0500 - 0900	10	37	42	38
0900 - 1200	16	37	39	37
1200 - 1500	3	36	41	38
1500 - 1800	7	36	40	38

[a]Number of 1/2 periods.
[b]No significant differences among times (ANOVA).

APPENDIX E. SEX RATIOS IN WINTERING WATERFOWL ON THE DETROIT RIVER

Overall sex ratios found in the winter of 1981 are shown in Table E1. Individual species differences are discussed below.

GOLDENEYE

First year males have a plumage similar to females in the late fall and early winter. The two are therefore difficult to distinguish until the young males begin to develop the characteristic white facial patch. According to Palmer (1975), this plumage usually begins to appear in the fall, but in some individuals it is not evident until winter. On the Detroit River, immature males were not distinguishable from females until early February. Thus, the percentage male figure for January can be considered the same as adult males for this period, whereas the percentage male figure for February and March includes both juvenile and adult males.

The proportion of males dropped markedly between the January 8-17 and January 18-27 survey, continued to decrease until February 16, and then rose again between February 17-26. The sex ratio also varied by site, although not by flock size (Table E2). Nilsson (1970b) observed a significant variation in sex ratio throughout the winter among goldeneye in Sweden. He also noted variation between flock composition at inland and coastal sites. He attributed the high proportion of females at certain sites to their greater need to stay in shallow water where feeding was energetically more economical. In Europe, female and immature goldeneyes migrate further to the south than adult males, because their smaller body size makes them less suited to wintering in a harsh climate. That does not seem to be the case on the Detroit River, where the average sex ratio through the winter was 51.7% male. It is possible that goldeneye wintering north of our study area in North America exhibit a skewed sex ratio similar to the north European ducks, but no literature is available to confirm this hypothesis.

SCAUP

The proportion of male scaup on the Detroit River averaged 69% throughout the winter and did not vary significantly from site to site. The number of males increased significantly after March 8. This increase was thought to be due to an early migration of males from the south. Nilsson (1970b) suggests that male scaup in Sweden migrate north before females, and he too noted an increasing proportion of males as April approached. However, in Sweden, female scaup predominated through the early winter.

The percentage of male scaup was significantly higher in medium sized flocks (51-200) than in small and large flocks (Table E2). This is a different pattern than seen in the canvasback and redhead where, in general, the proportion of males increased with flock size.

Table E1. Diving Duck Sex Ratios, January through March, 1981.

Species	Per cent male	Standard deviation
Goldeneye	51.7	21.8
Scaup	69.0	17.5
Canvasback	68.8	17.7
Redhead	74.5	15.4
Bufflehead	56.3	29.5
Common merganser	52.7	30.9

Table E2. Diving Ducks Sex Ratios[a], January through March, 1981.

Species	Flock size			
	2 to 50	51 to 100	101 to 200	201 to 2000
Goldeneye	48.0(80)	54.5(15)	53.6(10)	56.4(2)
Scaup	65.8(38)[a]	81.3(4)[b]	74.0(14)[ab]	69.7(20)
Canvasback	61.5(38)[a]	56.7(3)[a]	71.6(7)[b]	76.1(18)[c]
Redhead	72.8(34)	66.7(11)	77.4(3)	80.9(5)
Bufflehead	55.2(45)	----	----	----
Common merganser	53.6(19)	61.5(5)	65.3(2)	47.1(2)

[a]Percent males given with numbers in parentheses representing the number of flocks counted. Flock size categories show significantly different ratios if they do not share a letter in common (pairwise comparisons, $p = 0.05$ level of significance).

CANVASBACK

Much interest has been expressed in the sex ratio of canvasbacks, because this species is thought to exhibit the most disparate sex ratio (65-70% male) of all North American ducks (Nichols and Haramis 1980a). The low reproductive potential implied by this ratio is of much concern to waterfowl biologists and managers.

Nichols and Haramis (1980b) found mortality rates for canvasbacks to be significantly higher in females than in males. In a study of winter band recoveries, they also discovered a significantly different winter distribution pattern between males and females (Nichols and Haramis 1980a). Females from particular breeding areas tend to winter further south than males from the same areas.

On the Detroit River, an average of 68.8% of the wintering canvasbacks were males. This ratio changed between sites on the river, and between different flock sizes. However, among canvasbacks, flock size and river site were closely correlated. Large canvasback flocks occurred at the Mud Island and Horse Island sites, while smaller groups were seen at the remaining sites on the river.

Several authors have recorded the tendency for sex ratios in diving flocks to become more uneven as flock size increases. Nilsson (1970b) observed that males were more common in larger flocks of wintering goldeneye and tufted ducks in Scandinavia, while Welling and Sladen (1979) reported the same pattern of sex ratios in canvasback flocks in the Chesapeake Bay. On the Detroit River, a similar trend was observed for canvasback flocks (Table E2). Nilsson (1970b) reported that paired goldeneyes tended to leave large flocks and move into different feeding and resting areas, leaving unpaired ducks and surplus males behind. This may also be the case among canvasbacks on the Detroit River.

REDHEAD

Redhead flocks had the highest average proportion of adult males of all waterfowl observed. The sex ratio varied between sites (especially between Mud Island, where the redhead congregated in large flocks during the early winter), and the other areas on the river. The proportion of males declined steadily following February 26. This pattern is similar to that of the European pochard, as described by Nilsson (1970b). As in the redhead, adult male pochards predominated through the winter, but their numbers declined rapidly as spring approached due to their early migration north.

BUFFLEHEAD

Bufflehead were present in small flocks on the Detroit River throughout the winter, but were seen less frequently following the ice break-up. The sex ratio was nearly equal (56.3% male), and varied between most of the sites.

COMMON MERGANSER

Common mergansers were observed on the river from mid-January to the end of March. The proportion of adult males in a flock increased until February 6, after which it began a steady decline. The mean sex ratio of 52.7% male is in contrast to the 70% male flocks seen by Anderson et al. (1974) during December 1972 in Oklahoma. The common merganser sex ratio did not vary from site to site, nor with flock size (Table E2).

APPENDIX F. AERIAL PHOTOGRAPHS OF WETLAND STUDY PLOTS IN DULUTH-SUPERIOR HARBOR

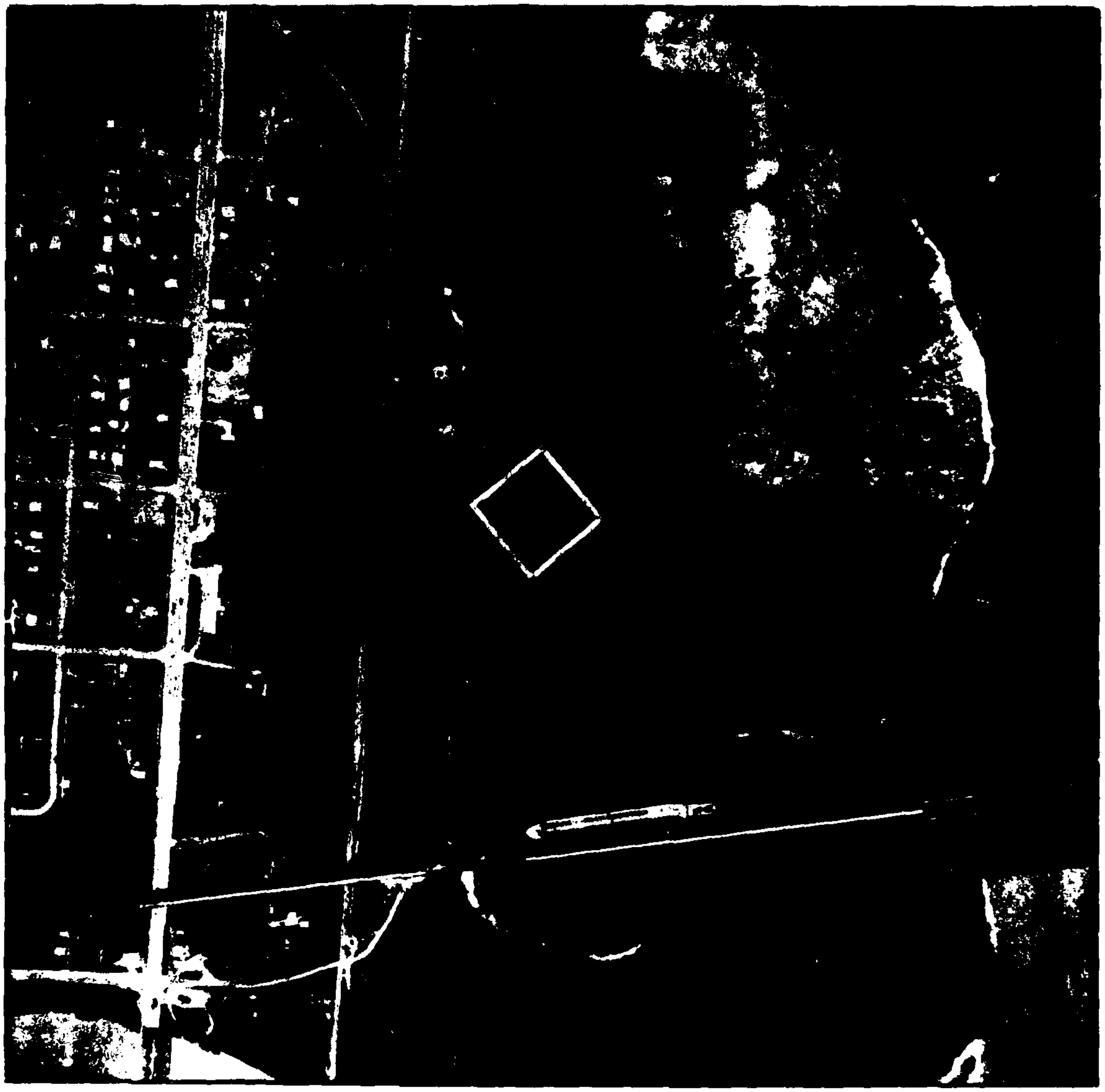

Figure F1. Hog Island wetland study plot, Duluth (from 2000').

Figure F2. Nemadji River wetland study plot, Duluth (from 2000').

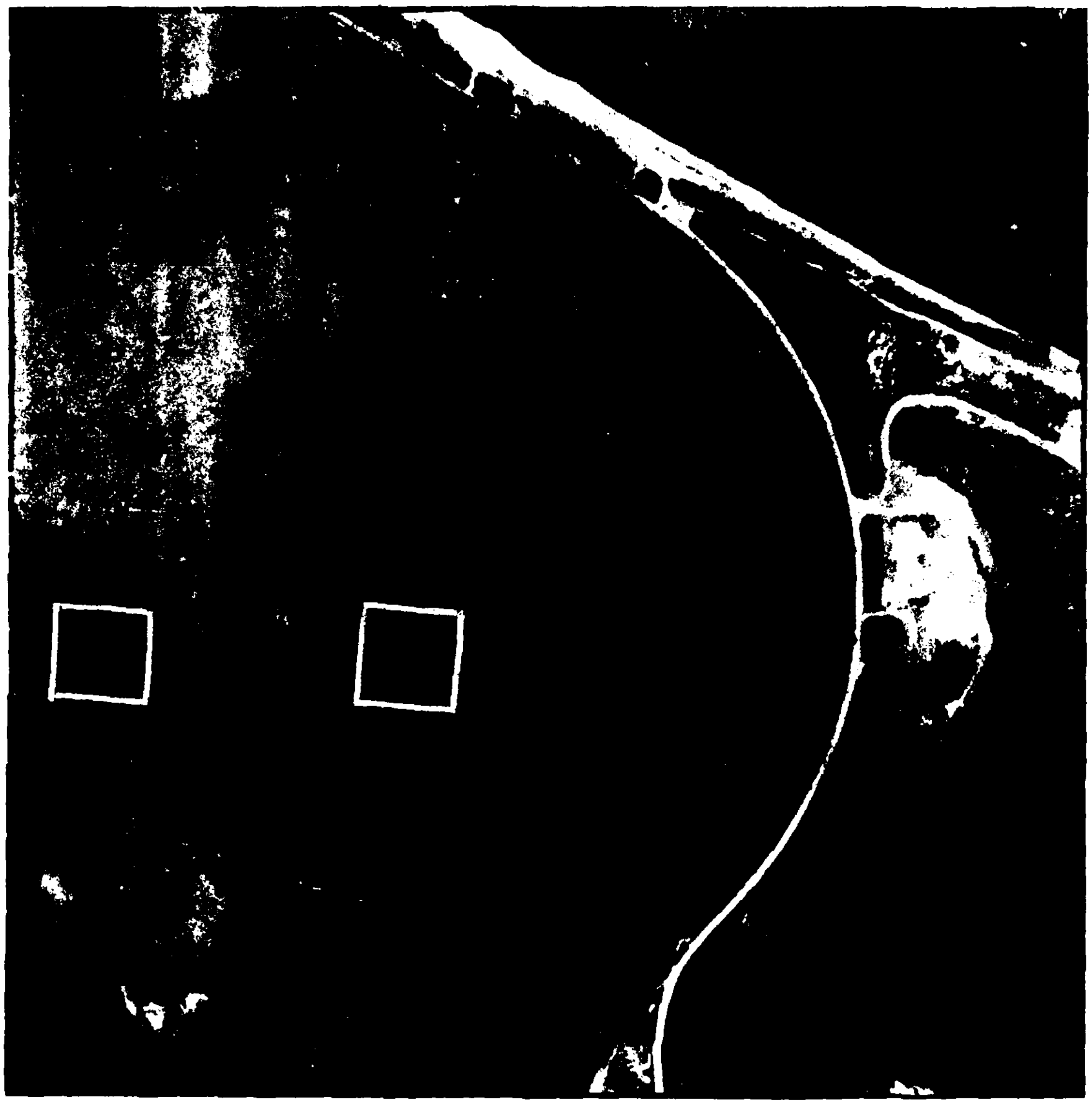

Figure F3. Allouez Bay wetland study plots (#1 and #2), Duluth (from 2000').

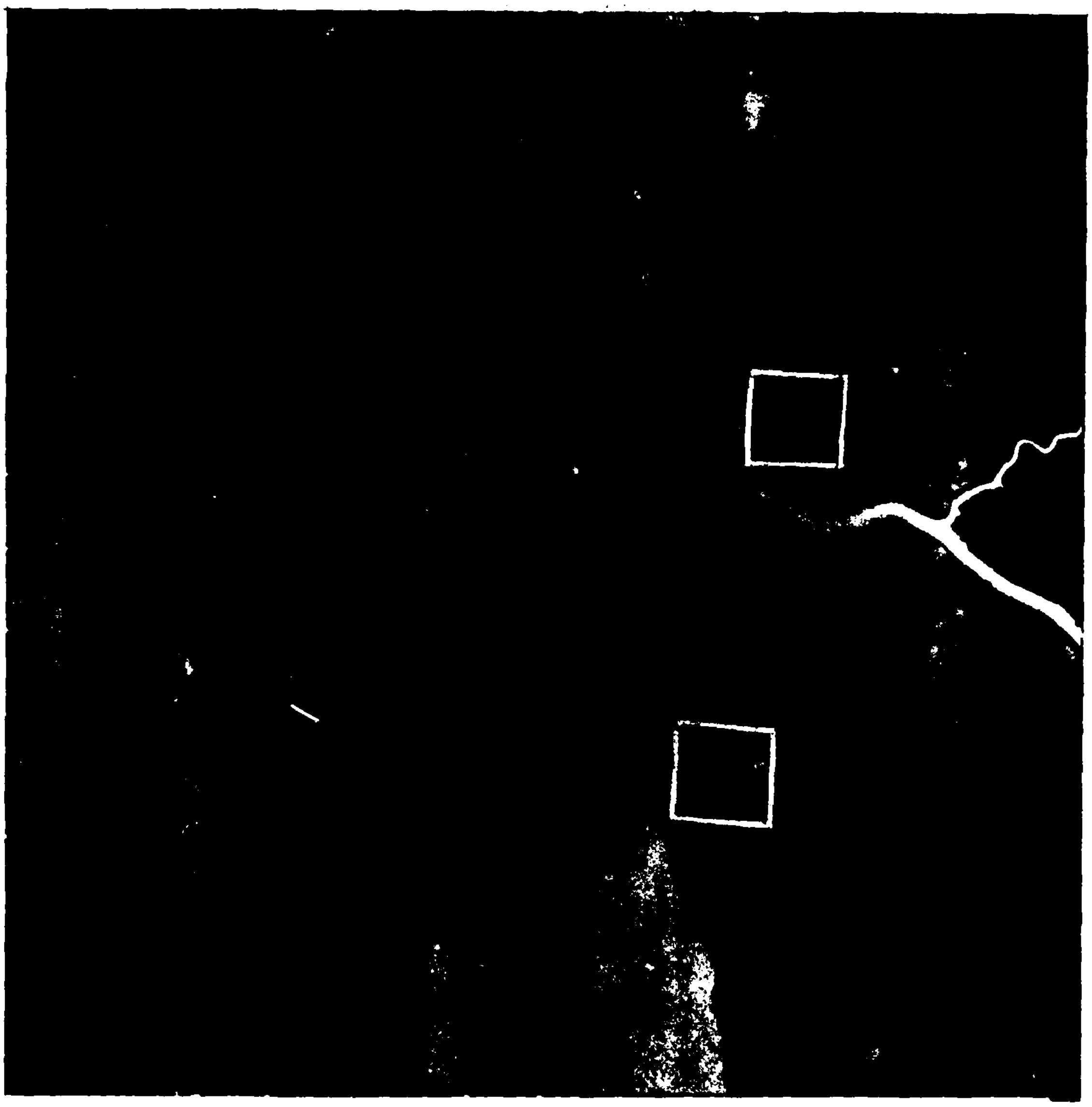

Figure F4. Allouez Bay wetland study plots (#3 and #4), Duluth (from 2000').

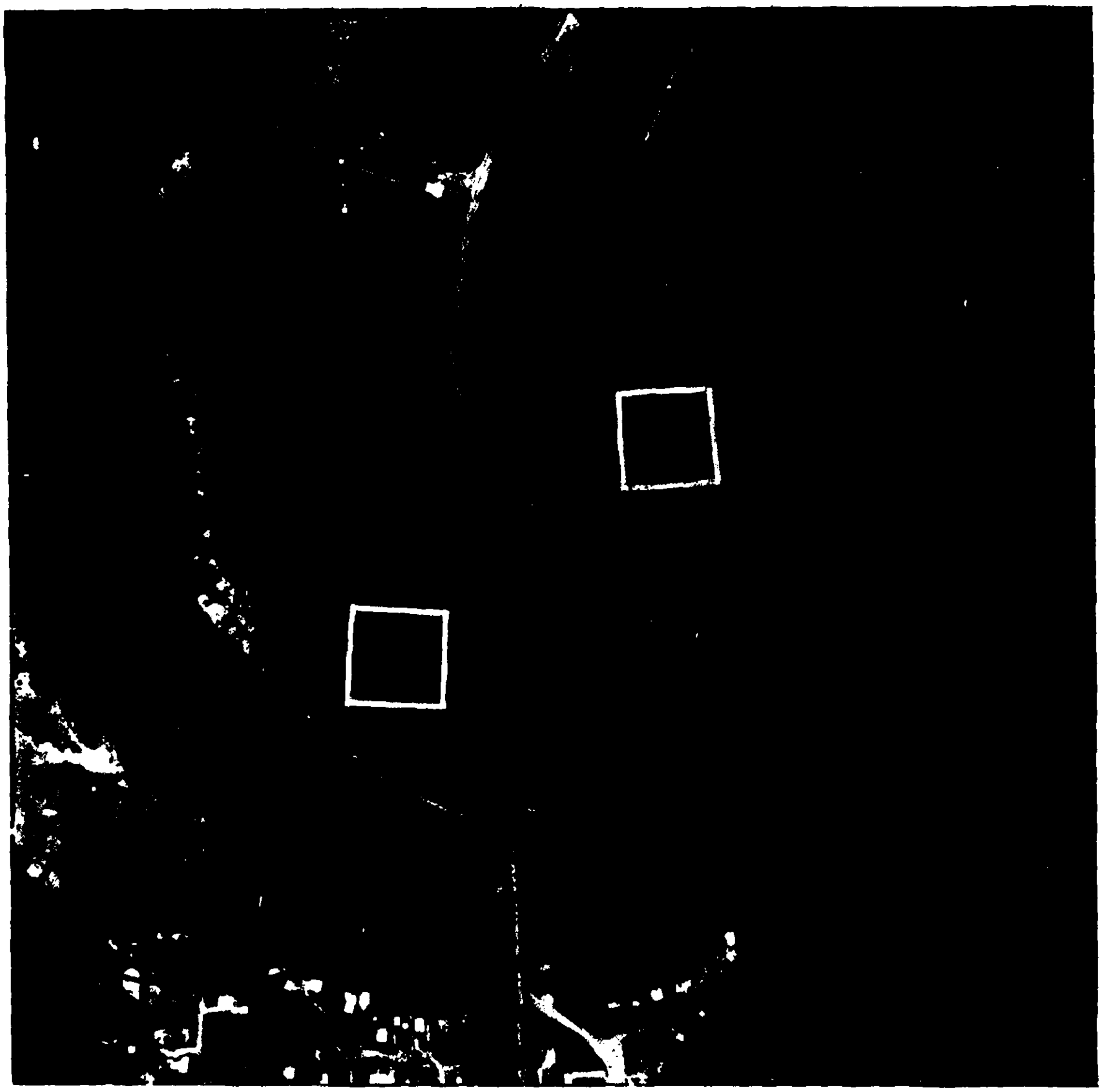

Figure F5. Oliver Bridge and Mud Lake wetland study plots, Duluth (from 2000').

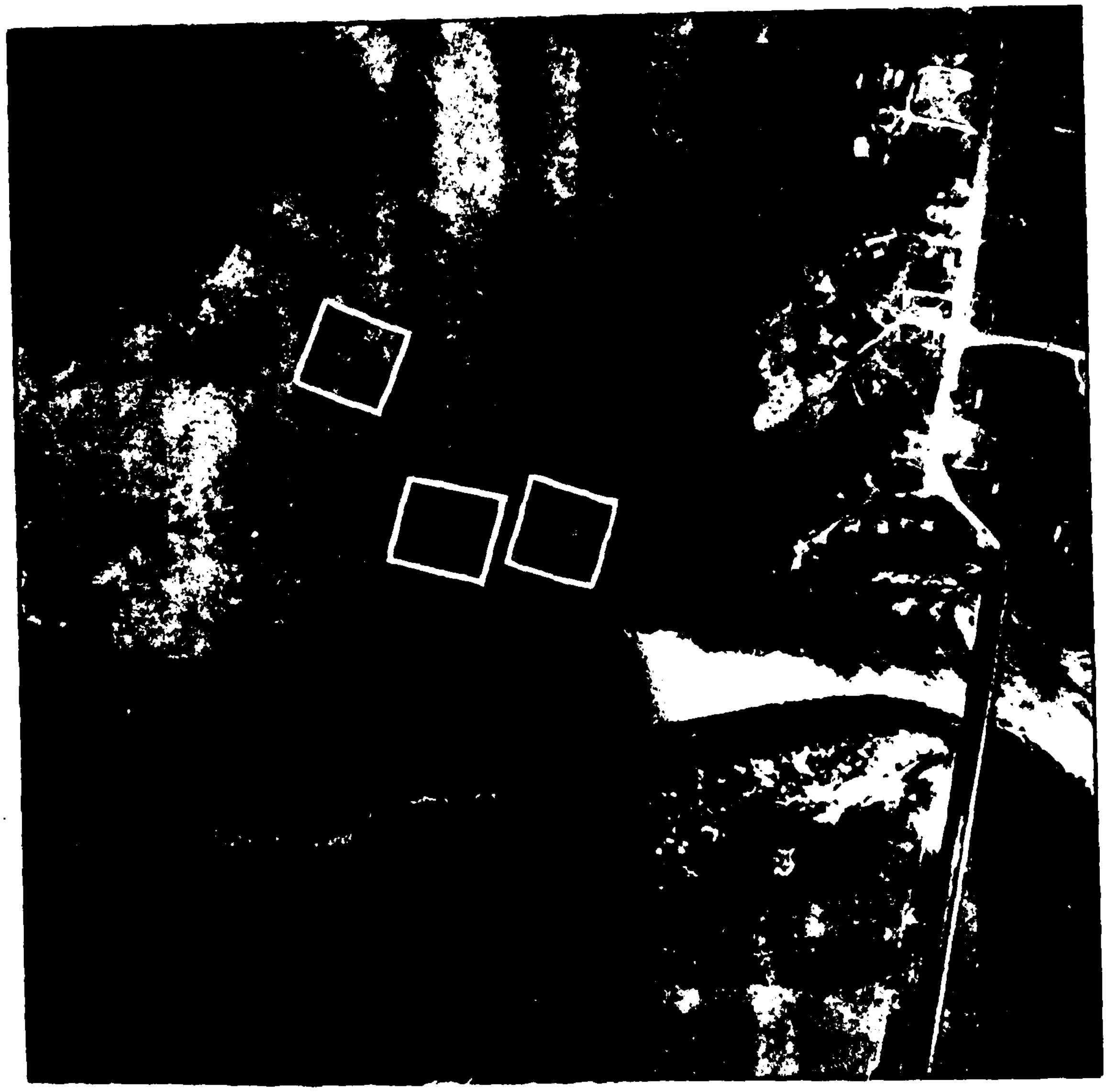

Figure F6. South Spirit Lake wetland study plots (#1, #2, and #3), Duluth (from 2000').

Figure F7. Spirit Lake Point wetland study plot, Duluth (from 2000').

APPENDIX G. SUMMARY TABLES OF DOMINANT WETLAND VEGETATION AND SITE ACCOUNTS, DULUTH HARBOR AND ST. MARY'S RIVER

APPENDIX G. DESCRIPTIONS OF INDIVIDUAL WETLAND STUDY SITES

The following accounts present site by site summaries of the vegetation and breeding bird populations of each study plot. General physical information regarding each site is presented also.

DULUTH

Hog Island (exposed to shipping - summer and winter)

This wetland is located between Hog Island and the mainland of Wisconsin (Figure 29). Loading docks for iron ore lie immediately to the east (within 0.3 km), but at present are inactive. The main shipping channel is located about 1/4 km northeast of this site, but there is no direct exposure to the shipping lane since Hog Island lies between the wetland and the channel. The only water connection between the wetland and the main harbor are two small channels, thus direct impacts (e.g., erosion due to ship wakes) seem unlikely.

The vegetation within this marsh was primarily cattail-sedge hummocks. *Typha* comprised 21% and *Carex* 13% by relative cover (Table G1). Some stratification was apparent. The shoreline was almost exclusively arrowhead (*Sagittaria latifolia*), but this graded into burreed (*Sparganium*) and sedges and eventually cattail-sedge in the innermost portions. Overall species richness was moderately high (N=21 taxa).

While little woody vegetation was present within the 1 ha study plot, willows (*Salix*) were abundant along the northern boundary and hardwood trees (e.g., *Populus*) dominated both the northwest edge of the marsh and the nearby areas of Hog Island. Hog Island is a dredge deposition island which was first created in the early 1900's. With the exception of an open sandy area in the middle, it is now covered by willow and aspen. The wetland itself is small (< 5 ha).

Water depths in 1979 varied from near 50 cm along the open water interface to only 10 cm in interior portions. Most of the marsh had 20-30 cm of standing water. In 1980 measured depths were lower (10-20 cm). This most likely reflects the fact that the harbor is affected by Lake Superior seiches. These often change water levels in the harbor by several centimeters. Currents caused by these seiches were observed flowing in and around the channels leading to this site.

The only breeding passerine found on this plot was the red-winged blackbird, although single mallard nests were also found both years of the study. Red-winged territory density was on the order of 50 per 10 ha. This species used bordering shrubs and trees as flocking sites. This site was also used as a feeding area by great blue herons and is known as a concentration area for post-breeding and migratory mallards and wood ducks (Niemi et al. 1977).

No obvious effects of shipping activity were noted.

Table G1. Dominant[a] Wetland Vegetation - Hog Island Plot.

Species[b]	Mean % cover ± S.D. 1979	Mean % cover ± S.D. 1980	Relative cover 1979	Relative cover 1980	Relative frequency 1979	Relative frequency 1980	Importance[c] value 1979	Importance[c] value 1980
Overall (shore to 100 m inland)	(N=40)	(N=20)						
Typha latifolia	14.3 ± 10.8%	16.1 ± 15.2%	21.4%	23.2%	15.8%	16.5%	18.6%	19.9%
Sparganium eurycarpum	13.5 ± 13.5	10.6 ± 11.2	20.3	15.3	12.9	15.3	16.6	15.3
Sagittaria latifolia	9.6 ± 8.6	18.4 ± 11.8	14.3	26.6	13.9	22.5	14.1	25.1
Carex spp.	8.6 ± 15.6	14.3 ± 22.4	12.8	20.7	8.1	10.6	10.5	15.7
Typha angustifolia	7.0 ± 9.4	6.7 ± 9.7	10.5	9.6	9.6	11.8	10.0	10.7
Near-shore (shore to 45 m inland)		(N=15)						
Sagittaria latifolia		13.7 ± 13.0		31.0		23.1		27.0
Sparganium eurycarpum		7.7 ± 10.8		17.4		17.3		17.4
Acorus calamus		7.7 ± 8.8		17.3		15.4		16.3
Typha latifolia		4.4 ± 8.1		10.1		13.5		11.8
Carex Spp.		5.7 ± 14.5		12.7		5.8		9.3
Typha angustifolia		3.3 ± 7.2		7.5		5.8		6.6
Lemna minor		0.4 ± 0.5		0.9		11.5		6.2
Shoreline (within 2 m open water)		(N=5)						
Sagittaria latifolia		37.0 ± 4.5		97.9		55.6		76.7
Lemna minor		0.8 ± 0.5		2.1		44.4		23.3

[a]Vegetation with importance value ≥ 5%.
[b]In order of decreasing "importance".
[c]Importance value = $\frac{\text{relative frequency + relative cover}}{2}$.

Nemadji River (exposed to shipping - summer and winter)

The Nemadji River wetland is located at the mouth of the river where it enters the Superior Harbor Basin (Figure 29). While it is in the general vicinity of both summer and winter shipping activity, it is not directly exposed to impact due to a slightly upriver location, well-developed banks, and the presence of dikes on both sides of the river. Proposed winter activity would take place at adjacent ore docks (ca. 1/4 km east), but the east dike prevents direct impact by ship passage.

Eighteen plant taxa were identified on this plot, but it was dominated by *Carex* hummocks (ca. 70% by relative cover, Table G2). While the plot itself was essentially free of woody vegetation, a narrow strip of alder-willow ran along the bank of the river and moderate sized hardwoods (e.g., *Populus*) were present within 20 m of the west border. The shoreline along the river was dominated by *Equisetum fluviatile*. Water depth varied from 9 cm to 49 cm, but the majority of the area was in the range from 20-30 cm deep.

The only breeding bird recorded on the plot either year was the red-winged blackbird, although both long-billed and short-billed marsh wrens nested in adjacent areas. Territory density of the red-wings was 33 and 46 per 10 ha during 1979 and 1980, respectively. The brushy border and particularly the adjacent wooded area served as flocking areas for the red-wings. The brushy shoreline was habituated by other species typical of this habitat including the yellowthroat, yellow warbler, and swamp sparrow.

No apparent shipping impact was noted.

Allouez Bay #1, #2, #3, #4 (exposed to shipping - summer and winter)

Allouez Bay is a rather extensive shallow water and wetland area. It is characterized by water less than six feet deep and mudflats which are alternately exposed and flooded as seiches and other water level changes occur. The shoreline of the bay includes approximately 100 ha of various types of wetlands including tamarack swamp, cattail-sedge, and other types of persistent and non-persistent emergent aquatic vegetation (Niemi et al. 1977).

In general, the wetlands in this area have higher plant diversity than the remainder of the Duluth sites studied. This applies both to interior portions and shoreline areas. This area lies 2-4 km east of present summer and proposed winter shipping activity.

Four plots were studied within Allouez Bay. Although vegetation sampling took place in all four during both years of this study, breeding birds were documented only during 1979 in plots #3 and #4. Breeding birds were censused both years in plots #1 and #2.

Allouez Bay is locally recognized as an important bird use area (Niemi et al. 1979). Large numbers of waterfowl and shorebirds have been observed during both spring and fall migrations. The bordering wetlands have consistently supported a small breeding population of black terns (ca. 15 pairs). This species has been declining in Wisconsin (Wisconsin DNR, pers. comm.) and its presence in Allouez Bay is therefore of particular interest.

Table G2. Dominant[a] Wetland Vegetation - Nemadji River Plot.

Species[b]	Mean % cover ± S.D. 1979	Mean % cover ± S.D. 1980	Relative cover 1979	Relative cover 1980	Relative frequency 1979	Relative frequency 1980	Importance value[c] 1979	Importance value[c] 1980
Overall (shore to 100 m inland)	(N=40)	(N=20)						
Carex spp.	46.5 ± 16.6%	48.6 ± 27.5%	68.2%	71.2%	27.0%	26.4%	47.6%	48.8%
Sparganium eurycarpum	7.1 ± 8.9	7.1 ± 8.7	10.4	10.4	14.2	16.7	12.3	13.5
Calla palustris	5.1 ± 7.1	3.0 ± 7.1	7.4	4.4	13.5	12.5	10.5	8.5
Potentilla palustris	2.7 ± 4.0	1.0 ± 1.8	3.9	1.5	13.5	11.1	8.7	6.3
Typha latifolia	2.9 ± 5.3	3.9 ± 7.7	4.3	5.7	8.8	16.7	6.5	11.2
Near-shore (shore to 45 m inland)		(N=15)						
Carex spp.		50.7 ± 15.7		89.2		35.7		62.5
Potentilla palustris		0.9 ± 1.7		1.6		14.3		8.0
Sparganium eurycarpum		1.9 ± 5.2		3.3		11.9		7.6
Calla palustris		1.4 ± 3.0		2.5		9.5		6.0
Shoreline (within 2 m open water)		(N=5)						
Equisetum fluviatile		52.0 ± 8.4		98.9		62.5		80.7
Potamogeton spp.		0.6 ± 1.2		1.2		37.5		19.3

[a] Vegetation with importance value ≥ 5%.
[b] In order of decreasing "importance".
[c] Importance value = $\frac{\text{relative frequency + relative cover}}{2}$.

Moderate numbers of great blue herons (20-30 individuals) feed in the bay also.

Plot #1 is located at the extreme southeast end of the bay and thus is some distance (ca. 4 km) from shipping activity. While the vegetation was primarily Carex (30% by relative cover, Table G3), this site included shrubs in the innermost portion and had a substantial amount of Potentilla palustris. Woody species present included alder, willows, and Myrica gale. This site was unique in that it was the only one in the Duluth study which had "stands" of Phragmites communis present. The innermost boundary was bordered by a tamarack marsh. The shoreline of this plot was rather definite and included a narrow band of brush. "Species" richness was one of the highest among the Duluth study plots (N=28 taxa). Water depths were mostly in the 10-20 cm range, but did occasionally reach 30 cm in the interior portions of the marsh. Areas near the shoreline were somewhat deeper (20-30 cm).

Breeding birds included red-winged blackbirds, long-billed marsh wrens, yellowthroats, soras, and swamp sparrows. This site was thus one of the more diverse plots in this regard. Red-wings dominated (ca. 60 territories per 10 ha). The yellowthroats and swamp sparrows reflect the presence of shrubs on the plot as well as the adjacent woody vegetation.

Plot #2 is located only 1/4 km west of site #1 and, although considered in the exposed to shipping treatment group, is approximately 4 km from the channel. Species richness was high (N=23 taxa), but the site was dominated by sedges (63% by relative cover)(Table G4). In contrast to plot #1, there was essentially no woody vegetation present on or adjacent to this plot. The nearest woody area lay along the southern edge of the wetland where upland hardwoods predominated, but this is more than 1/2 km from the actual study plot.

The shoreline had a low slope, and the transition from persistent to nonpersistent vegetation was thus gradual. The dominant shore species were Sagittaria latifolia and eelgrass (Eleocharis). Standing water on the plot varied from 15 cm to 60 cm in depth.

As in the case of plot #1, several breeding birds were recorded here Once again the red-winged blackbird dominated with a territory density of 50 per 10 ha. Black terns, although they did not nest on the plot itself, did nest in adjacent portions of the wetland. Large numbers (10-15) of great blue herons were often observed feeding in the general vicinity of this plot also.

Plot #3 is located along the "shore" of Bear Creek. The creek does have a definite channel, but no current is apparent most of the year and no raised banks are present. The nearest shipping channel is approximately 3 km to the east and a small peninsula of land lies between the plot and the open waters of Allouez Bay. Thus, while this plot has been assigned to the "exposed" treatment group, direct impact of shipping seems unlikely under present conditions.

The dominant vegetation on the site was sedge (Carex) and burreed (Sparganimum). These two taxa comprised 40% and 20% by relative cover of the plot (Table G5) "species" richness was moderate (N=20 taxa). Although no actual creek bank was apparent, the water depth did change abruptly near the edge of

Table G3. Dominant[a] Wetland Vegetation - Allouez Bay Plot #1.

Species[b]	Mean % cover ± S.D. 1979	Mean % cover ± S.D. 1980	Relative cover 1979	Relative cover 1980	Relative frequency 1979	Relative frequency 1980	Importance[c] value 1979	Importance[c] value 1980
Overall (shore to 100 m inland)	(N=40)	(N=20)						
Carex spp.	22.0 ± 13.7%	21.8 ± 12.9%	30.3%	40.4%	17.4%	21.3%	23.9%	30.8%
Potentilla palustris	11.9 ± 14.9	2.7 ± 4.7	16.4	4.9	11.7	8.5	14.1	6.7
Sagittaria latifolia	5.0 ± 5.3	2.5 ± 4.3	6.9	4.6	10.9	10.6	8.9	7.6
Equisetum fluviatile	7.2 ± 13.4	7.6 ± 13.8	9.9	14.0	5.7	6.4	7.8	10.2
Phragmites communis	7.0 ± 14.0	3.6 ± 9.5	9.7	6.6	5.2	5.3	7.5	6.0
Typha latifolia	3.5 ± 5.9	2.8 ± 6.0	4.8	5.1	6.1	6.4	5.5	5.7
Typha angustifolia	5.0 ± 12.9	4.0 ± 9.3	6.9	7.4	3.0	4.3	5.0	5.8
Sparganium eurycarpum	2.8 ± 4.5	2.3 ± 3.8	3.8	4.3	5.7	7.5	4.7	5.9
Near-shore (shore to 45 m inland)		(N=15)						
Carex spp.		13.9 ± 12.4		22.3		16.5		19.4
Phragmites communis		14.0 ± 11.8		22.5		12.1		17.3
Equisetum fluviatile		10.0 ± 9.1		16.1		12.1		14.1
Typha latifolia		10.0 ± 15.5		16.1		6.6		11.3
Potentilla palustris		4.8 ± 6.6		7.7		8.8		8.3
Shoreline (within 2 m open water)		(N=5)						
Carex spp.		23.0 ± 13.5		33.0		17.9		25.5
Sparganium eurycarpum		11.0 ± 7.4		15.8		14.3		15.1
Sagittaria latifolia		11.0 ± 11.4		15.8		14.3		15.1
Potentilla palustris		11.0 ± 12.4		15.8		10.7		13.3
Equisetum fluviatile		6.0 ± 6.5		8.6		10.7		9.7
Glyceria spp.		5.0 ± 6.1		7.2		10.7		9.0
Rumex spp.		2.2 ± 4.4		3.2		7.1		5.2

[a] Vegetation with importance value $\geq$ 5%.
[b] In order of decreasing "importance".
[c] Importance value = $\frac{\text{relative frequency} + \text{relative cover}}{2}$.

Table G4. Dominant[a] Wetland Vegetation - Allouez Bay Plot #2.

Species[b]	Mean % cover ± S.D.		Relative cover		Relative frequency		Importance[c] value	
	1979	1980	1979	1980	1979	1980	1979	1980
Overall (shore to 100 m inland)	(N=40)	(N=20)						
Carex spp.	47.1 ± 19.9%	34.3 ± 19.4%	63.2%	46.4%	17.7%	18.6%	40.4%	32.5%
Sagittaria latifolia	7.6 ± 5.2	10.8 ± 7.4	10.2	14.5	17.7	19.6	14.0	17.1
Sparganium eurycarpum	4.6 ± 4.2	11.6 ± 5.8	6.1	15.6	16.8	19.6	11.5	17.6
Potentilla palustris	7.1 ± 13.1	10.3 ± 12.0	9.5	13.9	7.7	12.8	8.6	13.3
Typha latifolia	2.8 ± 3.4	3.5 ± 4.0	3.7	4.7	8.6	9.8	6.2	7.3
Near-shore (shore to 45 m inland)		(N=15)						
Carex spp.		39.7 ± 24.1		44.8		16.5		30.6
Sagittaria latifolia		14.7 ± 9.2		16.6		19.0		17.8
Potentilla palustris		15.5 ± 14.4		17.5		15.2		16.3
Sparganium eurycarpum		7.2 ± 4.6		8.1		19.0		13.6
Typha latifolia		5.3 ± 5.5		6.0		11.4		8.7
Eleocharis spp.		5.1 ± 7.7		5.8		8.9		7.3
Shoreline (within 2 m open water)		(N=5)						
Sagittaria latifolia		16.0 ± 4.2		49.7		33.3		41.5
Eleocharis spp.		11.0 ± 5.5		34.2		33.3		33.8
Typha latifolia		1.2 ± 2.2		6.8		13.3		10.1
Potentilla palustris		2.0 ± 2.7		6.2		13.3		9.8

[a]Vegetation with importance value ≥ 5%.
[b]In order of decreasing "importance".
[c]Importance value = $\frac{\text{relative frequency + relative cover}}{2}$.

Table G5. Dominant[a] Wetland Vegetation - Allouez Bay Plot #3.

Species[b]	Mean % cover $\pm$ S.D. 1979	Mean % cover $\pm$ S.D. 1980	Relative cover 1979	Relative cover 1980	Relative frequency 1979	Relative frequency 1980	Importance[c] value 1979	Importance[c] value 1980
Overall (shore to 100 m inland)	(N=40)	(N=20)						
Carex spp.	28.7 $\pm$ 18.9%	32.8 $\pm$ 20.7%	40.4%	42.6%	14.3%	17.8%	27.3%	30.1%
Sparganium eurycarpum	14.3 $\pm$ 9.4	15.5 $\pm$ 10.1	20.2	20.2	16.3	18.5	18.3	19.3
Sagittaria latifolia	7.0 $\pm$ 4.7	6.2 $\pm$ 4.9	9.8	8.0	13.9	15.7	11.8	11.9
Potentilla palustris	7.7 $\pm$ 9.5	9.5 $\pm$ 12.7	10.9	12.4	11.0	8.3	11.0	10.3
Typha latifolia	4.0 $\pm$ 4.4	6.1 $\pm$ 5.5	5.7	7.9	9.0	13.9	7.3	10.9
Near-shore (shore to 50 m inland)		(N=15)						
Sparganium eurycarpum		26.3 $\pm$ 15.3		35.2		17.7		26.4
Potentilla palustris		7.7 $\pm$ 5.9		10.3		14.1		12.2
Sagittaria latifolia		8.1 $\pm$ 7.7		10.8		11.7		11.3
Scirpus spp.		9.1 $\pm$ 13.9		12.1		8.2		10.2
Carex spp.		10.0 $\pm$ 16.9		13.4		5.9		9.6
Typha latifolia		6.0 $\pm$ 5.7		8.0		10.6		9.3
Spirodella polyrhiza		1.9 $\pm$ 3.0		2.5		8.2		5.4
Salix spp.		3.3 $\pm$ 5.2		4.5		5.9		5.2
Shoreline (within 2 m open water)		(N=5)						
Sparganium eurycarpum		33.0 $\pm$ 9.7		77.1		35.7		56.4
Sagittaria latifolia		7.2 $\pm$ 5.4		16.8		28.6		22.7
Potentilla palustris		1.4 $\pm$ 2.1		3.3		21.4		12.4
Carex spp.		1.2 $\pm$ 2.2		2.8		14.3		8.6

[a] Vegetation with importance value $\geq$ 5%.
[b] In order of decreasing "importance".
[c] Importance value = $\frac{\text{relative frequency} + \text{relative cover}}{2}$.

the plot. This is reflected in the low diversity of the shoreline vegetation (N=4 taxa). Water depths on the plot itself ranged from 20 to 30 cm.

Only three breeding bird species were recorded on this plot, and the redwinged blackbird dominated (54 territories per 10 ha). Other bird use of the site was as described for Allouez Bay in general.

Plot #4 lies almost directly west of plot #3 and almost 2.5 km from the shipping lane. Similar to the other Allouez Bay plots, it was dominated by sedges (Carex) (41% by relative cover) and had relatively high "species" richness (N=27 taxa)(Table G6). It was unique in that it had a significant amount of Menyanthes trifoliata and Myrica gale as well as scattered willows (Salix) and swamp birch (Betula pumila). It thus was far brushier than the other sites. The border between this wetland area and the open water of the bay was rather definite and was comprised of an elevated bank with a narrow brushy strip.

The breeding bird population on this plot was diverse and included five species. The red-winged blackbird dominated (60 territories per 10 ha), but mallard, Virginia rail, yellowthroat, and swamp sparrow were also present. The latter two species were probably present due to the shrubby nature of the site.

Oliver Bridge (unexposed to shipping)

This marsh is located just upriver of the Oliver Bridge on the Minnesota side of the St. Louis River (Figure 29). Since the nearest area of winter or summer shipping activity is several km downriver, this site is quite removed from shipping impacts. The river does have a current, although only moderate at this point and the border of the marsh is riverine.

The wetland is predominantly sedge (Carex) (55% by relative cover), but includes scattered cattails also (Table G7). Several other species were represented including arrowhead (Sagittaria latifolia) which dominated the shoreline vegetation. Total "species" richness was 23.

There was no woody vegetation on the plot itself, but the shoreline included a narrow band of willow and alder, and the western edge of the wetland was bounded by upland hardwoods. Water depth varied from 10 cm to 45 cm and was most commonly in the 25 cm to 35 cm range.

Only three breeding bird species were recorded on this plot--the red-winged blackbird, swamp sparrow, and long-billed marsh wren. The red-winged blackbird was the most abundant, although not by nearly as large a margin as on most plots. Other species observed include moderate number of cliff swallows which fed on the site and occasional great blue herons which fed in the shoreline areas.

Mud Lake (unexposed to shipping)

This site is located just on the downriver side of the Oliver Bridge on the Minnesota shoreline (Figure 29). As such it is well upriver from any shipping activity, summer or winter. Since it is situated in Mud Lake, a

Table G6. Dominant[a] Wetland Vegetation - Allouez Bay Plot #4.

Species[b]	Mean % cover ± S.D. 1979	Mean % cover ± S.D. 1980	Relative cover 1979	Relative cover 1980	Relative frequency 1979	Relative frequency 1980	Importance[c] value 1979	Importance[c] value 1980
Overall (shore to 100 m inland)	(N=40)	(N=20)						
Carex spp.	33.9 ± 17.1%	31.8 ± 16.3%	40.9%	45.8%	15.8%	19.4%	28.4%	32.6%
Menyanthes trifoliata	15.1 ± 17.8	18.8 ± 19.1	18.3	27.0	7.7	12.6	13.0	19.8
Potentilla palustris	6.2 ± 11.0	3.6 ± 6.9	7.5	5.2	9.7	7.8	8.6	6.5
Sagittaria latifolia	5.8 ± 6.3	3.2 ± 3.7	7.0	4.5	9.7	11.7	8.4	8.1
Myrica gale	7.5 ± 13.2	5.3 ± 9.2	9.1	7.6	6.1	9.7	7.6	8.7
Sparganium eurycarpum	2.5 ± 2.4	3.4 ± 4.9	3.1	4.8	4.5	8.7	3.8	6.8
Salix spp.	2.3 ± 4.8	0.5 ± 1.2	2.8	0.7	7.7	4.9	5.2	2.8
Near-shore (shore to 45 m inland)		(N=15)						
Carex spp.		33.0 ± 22.6		40.2		16.3		28.2
Sagittaria latifolia		14.3 ± 8.8		17.9		18.8		18.1
Typha latifolia		12.0 ± 8.0		14.6		15.0		14.8
Potentilla palustris		10.1 ± 11.0		12.3		13.8		13.0
Salix spp.		4.7 ± 7.4		5.8		8.8		7.3
Myrica gale		4.7 ± 8.6		5.7		6.3		6.0
Shoreline (within 2 m open water)		(N=5)						
Sagittaria latifolia		21.0 ± 8.9		47.1		26.3		36.7
Sparganium eurycarpum		13.0 ± 4.5		29.1		26.3		27.7
Carex spp.		5.2 ± 4.8		11.7		21.1		16.4
Potentilla palustris		5.2 ± 6.9		7.2		15.8		11.5
Myrica gale		2.2 ± 4.4		4.9		10.5		7.7

[a] Vegetation with importance value ≥ 5%.
[b] In order of decreasing "importance".
[c] Importance value = $\frac{\text{relative frequency + relative cover}}{2}$.

Table G7. Dominant[a] Wetland Vegetation - Oliver Bridge Plot.

Species[b]	Mean % cover ± S.D. 1979	Mean % cover ± S.D. 1980	Relative cover 1979	Relative cover 1980	Relative frequency 1979	Relative frequency 1980	Importance[c] value 1979	Importance[c] value 1980
Overall (shore to 100 m inland)	(N=40)	(N=20)						
Carex spp.	45.8 ± 14.1%	46.5 ± 13.0%	54.9%	66.0%	18.2%	22.5%	36.5%	44.2%
Sagittaria latifolia	8.3 ± 5.1	7.8 ± 4.6	10.0	11.1	17.7	22.5	13.9	16.8
Potentilla palustris	11.7 ± 15.4	0.0	14.0	0.0	11.8	0.0	12.9	0.0
Calla palustris	5.1 ± 5.3	3.1 ± 3.7	6.1	4.3	15.0	11.2	10.5	7.8
Typha latifolia	5.4 ± 5.1	4.3 ± 5.9	6.5	6.1	12.3	11.2	9.4	8.7
Near-shore (shore to 45 m inland)		(N=15)						
Carex spp.		33.7 ± 16.5		41.5		16.0		28.7
Potentilla palustris		22.7 ± 16.1		28.0		16.0		22.0
Sagittaria latifolia		10.0 ± 5.4		12.3		16.0		14.2
Typha latifolia		5.5 ± 6.0		6.7		11.7		9.2
Calla palustris		3.9 ± 5.4		4.8		10.6		7.7
Shoreline (within 2 m open water)		(N=5)						
Sagittaria latifolia		25.0 ± 6.1		94.7		62.5		78.6
Typha latifolia		1.2 ± 2.2		4.5		25.0		14.8
Carex spp.		0.2 ± 0.4		0.8		12.5		6.7

[a] Vegetation with importance value ≥ 5%.
[b] In order of decreasing "importance".
[c] Importance value = $\frac{\text{relative frequency + relative cover}}{2}$.

backwater area of the St. Louis River, it is not part of a lotic regime.

The dominant vegetation throughout the marsh was sedge (Carex) (64% by relative cover, Table G8). This included the shoreline. Scattered cattails were present in some areas, and a few shrubs grew along the shoreline. Total "species" richness was 23.

The plot is located on a NNE facing shore and is exposed to appreciable wave action since northeast winds are common, and there is a considerable fetch along this axis. This could account for the lack of diversity in the shoreline vegetation as well as the rather abrupt change from open water to sedge marsh.

Three bird species were found breeding on this plot including the red-winged blackbird, long-billed marsh wren, and swamp sparrow. These species nested at similar densities (ca. 30 territories per 10 ha). The long-billed marsh wren nested at one of its highest densities in the study area on this plot.

Spirit Lake Marshes (unexposed to shipping)

This wetland is one of the largest in the lower St. Louis River--Duluth Harbor area (ca. 120 acres), and three study plots were located within it. It is located well upriver and therefore is not subjected to either summer or winter shipping activity.

The shoreline of the marsh is variable in nature. Along the western edge, it is exposed to a riverine situation since the main flow of the river passes nearby. The current is slow with the exception of the spring runoff period. The west boundary therefore has a definite bank, although it is low. This bank supports a narrow band of brushy vegetation (primarily willows). In contrast, the eastern edge of the wetland interfaces with a large backwater bay of the river. This area is quite shallow and has no current. The shoreline of the wetland here is therefore less well defined and has no obvious bank.

As a whole, the area is predominantly a cattail-sedge type wetland. It is bordered by upland hardwoods on the southeast. Although the overall vegetation is cattail-sedge, differences between the three study plots did exist. Plot #1 was a true cattail-sedge site, as Carex and Typha comprised 40% and 15% relative cover of the plot (Table G9). Wild calla (Calla palustris) was common also. The shoreline of this plot was a mix of arrowhead (Sagittaria latifolia) and horsetail (Equisetum spp.) with cattails interspersed.

Plot #2 was also predominantly cattail-sedge, but the cattail density was somewhat lower than in plot #1 (Table G10). In contrast to plot #1, this site had very little wild calla and the shoreline was a mix of cattail and bur reed (Sparganium eurycarpum).

Plot #3 was markedly different from the other two in that the most abundant species was wild calla (30% by relative cover, Table G11). Moderate amounts of Typha and Carex were present also. The shoreline was almost exclusively burreed and arrowhead.

Breeding bird populations on these three plots were similar. The red-winged blackbird was the most abundant and had a territory density ranging from

Table G8. Dominant[a] Wetland Vegetation - Mud Lake Plot.

Species[b]	Mean % cover ± S.D. 1979	Mean % cover ± S.D. 1980	Relative cover 1979	Relative cover 1980	Relative frequency 1979	Relative frequency 1980	Importance[c] value 1979	Importance[c] value 1980
Overall (shore to 100 m inland)	(N=40)	(N=20)						
Carex spp.	51.5 ± 22.3%	57.3 ± 12.6%	63.5%	71.1%	19.4%	21.1%	41.4%	46.1%
Calla palustris	11.8 ± 10.7	10.6 ± 7.1	14.6	13.2	15.9	20.0	15.3	16.6
Typha latifolia	5.2 ± 5.9	3.6 ± 5.8	6.4	4.5	11.1	9.5	8.8	7.0
Potentilla palustris	2.9 ± 3.8	2.9 ± 4.6	3.6	3.6	11.1	9.5	7.4	6.5
Sagittaria latifolia	3.1 ± 4.1	3.2 ± 4.3	3.9	4.0	9.7	12.6	6.8	8.3
Near-shore (shore to 45 m inland)		(N=15)						
Carex spp.		27.0 ± 26.2		43.5		13.0		28.2
Typha latifolia		11.1 ± 6.6		17.9		19.5		18.7
Calla palustris		13.4 ± 13.3		21.6		14.3		17.9
Potentilla palustris		3.8 ± 5.4		6.1		10.4		8.3
Sparganium eurycarpum		3.5 ± 4.8		5.6		10.4		8.0
Shoreline (within 2 m open water)		(N=5)						
Carex spp.		51.0 ± 11.4		85.9		50.0		68.0
Typha latifolia		8.4 ± 7.1		14.1		50.0		32.1

[a] Vegetation with importance value $\geq$ 5%.
[b] In order of decreasing "importance".
[c] Importance value = $\frac{\text{relative frequency + relative cover}}{2}$.

Table G9. Dominant[a] Wetland Vegetation - South Spirit Lake Plot #1.

Species[b]	Mean % cover ± S.D. 1979	Mean % cover ± S.D. 1980	Relative cover 1979	Relative cover 1980	Relative frequency 1979	Relative frequency 1980	Importance[c] value 1979	Importance[c] value 1980
Overall (shore to 100 m inland)	(N=30)	(N=20)						
Carex spp.	28.3 ± 14.8%	32.5 ± 17.7%	40.0%	41.1%	16.8%	17.6%	28.3%	29.3%
Calla palustris	13.0 ± 9.1	12.1 ± 8.5	18.3	15.3	15.6	16.7	17.0	16.0
Typha latifolia	10.9 ± 5.5	12.1 ± 5.8	15.3	15.2	16.2	18.5	15.7	16.9
Potentilla palustris	5.1 ± 5.7	7.0 ± 7.3	7.1	8.8	10.1	13.0	8.6	10.9
Sagittaria latifolia	4.5 ± 5.9	7.6 ± 10.5	6.4	9.5	8.9	10.2	7.7	9.9
Sparganium eurycarpum	4.2 ± 8.8	5.5 ± 11.2	5.9	7.0	4.5	5.6	5.2	6.3
Near-shore (shore to 45 m inland)		(N=15)						
Calla palustris		14.7 ± 6.4		21.1		16.9		19.0
Carex spp.		16.3 ± 13.2		23.4		12.4		17.9
Typha latifolia		12.3 ± 5.9		17.7		16.9		17.3
Sagittaria latifolia		12.0 ± 12.4		17.2		11.2		14.2
Spirodella polyrhiza		3.0 ± 4.4		4.3		11.2		7.8
Potentilla palustris		2.8 ± 3.6		4.0		9.0		6.5
Sparganium eurycarpum		4.3 ± 9.0		6.2		4.5		5.4
Shoreline (within 2 m open water)		(N=5)						
Sagittaria latifolia		21.0 ± 7.4		58.0		41.7		49.9
Equisetum spp.		14.0 ± 6.5		38.7		41.7		40.2
Typha latifolia		1.2 ± 2.2		3.3		16.7		10.0

[a]Vegetation with importance value $\geq$ 5%.
[b]In order of decreasing "importance".
[c]Importance value = $\frac{\text{relative frequency + relative cover}}{2}$.

Table G10. Dominant[a] Wetland Vegetation - South Spirit Lake Plot #2.

Species[b]	Mean % cover ± S.D. 1979	Mean % cover ± S.D. 1980	Relative cover 1979	Relative cover 1980	Relative frequency 1979	Relative frequency 1980	Importance[c] value 1979	Importance[c] value 1980
Overall (shore to 100 m inland)	(N=30)	(N=20)						
Carex spp.	39.2 ± 18.4%	43.3 ± 19.4%	15.2%	54.7%	18.4%	19.4%	36.8%	37.1%
Typha latifolia	6.9 ± 5.6	8.1 ± 5.6	9.7	10.2	15.2	16.5	12.4	13.3
Potentilla palustris	8.1 ± 9.6	9.1 ± 11.3	11.4	11.4	12.7	11.7	12.0	11.6
Sagittaria latifolia	5.4 ± 4.4	7.1 ± 6.9	7.7	9.0	15.2	15.5	11.4	12.3
Sparganium eurycarpum	6.0 ± 4.9	8.3 ± 7.8	8.5	10.4	13.9	13.6	11.2	12.0
Calla palustris	3.5 ± 4.6	2.7 ± 4.3	5.0	3.4	8.9	9.7	6.9	6.6
Near-shore (shore to 45 m inland)		(N=15)						
Carex spp.		35.7 ± 14.0		49.1		17.4		33.3
Typha latifolia		7.8 ± 6.1		10.7		15.1		12.9
Sagittaria latifolia		7.5 ± 5.5		10.3		15.1		12.7
Sparganium eurycarpum		7.3 ± 5.3		10.1		14.0		12.0
Potentilla palustris		8.8 ± 10.1		12.1		11.6		11.9
Calla palustris		3.1 ± 4.9		4.3		8.1		6.2
Shoreline (within 2 m open water)		(N=5)						
Typha latifolia		11.2 ± 7.0		41.8		31.3		36.6
Sparganium eurycarpum		10.0 ± 3.5		37.3		31.3		34.3
Potentilla palustris		4.2 ± 6.4		15.7		18.7		17.2
Acorus calamus		1.4 ± 2.1		5.2		18.7		12.0

[a] Vegetation with importance value $\geq$ 5%.
[b] In order of decreasing "importance".
[c] Importance value = $\frac{\text{relative frequency} + \text{relative cover}}{2}$.

43 to 50 per 10 ha. The long-billed marsh wren was present on each plot also, and its density varied from 4 to 28 territories per 10 ha. These abundant species did increase appreciably on each plot from 1979 to 1980.

Additional species which have been known to nest in this area include the American bittern, sora and Virginia rails, pied-billed grebe, and black tern. The latter species has nested in the northeast tip of the wetland (ca. 24 pairs) (Davis et al. 1978). Other birds using the area include large numbers of swallows which fed over the site, great blue herons, and occasionally yellow-headed blackbirds.

Spirit Lake Point (unexposed to shipping)

This wetland is located on the north side of Spirit Lake Point and is far removed from shipping activity. The vegetation was predominantly sedge (*Carex*) (63% relative cover), but included *Typha* and *Sagittaria* also (Table G12). Similar to the Mud Lake plot, this site is exposed to considerable wave action since strong northeast winds are common and there is a large fetch in that direction. This probably accounts for the fact that there is a definite shoreline and an abrupt transition from non-persistent to persistent vegetation. The low diversity (N=3 taxa) of the shoreline vegetation also is probably a reflection of this situation. The southern edge of the marsh quickly grades into the upland hardwood forest present on Spirit Lake Point.

The breeding bird populations were unusual in that the long-billed marsh wren was the most abundant, perhaps due to the dominance by sedges. This site had the highest population of this species in the Duluth study area. The red-winged blackbird was also fairly abundant. Other species known to nest in the area, although not on the study plot, include the yellow-headed blackbird. This species is a rare breeder in this part of Minnesota.

St. Mary's River

Mike's Landing Culvert (exposed to shipping)

This site is located approximately 2.5 km southwest of Point Aux Frenes on the north side of the boat channel to Mike's Landing. It lies within 2.5 km of the shipping lane (winter and summer) and thus is considered "exposed" to shipping.

The marsh consisted of well-developed hummocks dominated by *Carex* (74% relative cover, Table G13). A few small willows (*Salix interior*) were scattered throughout the site also. Species richness was low (9 taxa identified). Water depth ranged from 30 to 100 cm, but in most areas was near 50 cm. A large amount of detritus, which appeared to have been washed in by ship wakes, was present along the shoreline.

The breeding bird population on this plot was dominated by the red-winged blackbird (88 territories/10 ha). The only other nesting species found on the plot was the long-billed marsh wren. Black terns nested along the nearby shoreline, primarily on the detritus already noted above.

Table G11. Dominant[a] Wetland Vegetation - South Spirit Lake Plot #3.

Species[b]	Mean % cover ± S.D. 1979	Mean % cover ± S.D. 1980	Relative cover 1979	Relative cover 1980	Relative frequency 1979	Relative frequency 1980	Importance[c] value 1979	Importance[c] value 1980
Overall (shore to 100 m inland)	(N=30)	(N=20)						
Calla palustris	23.4 ± 20.6%	19.0 ± 13.8%	29.9%	24.4%	15.4%	19.2%	22.7%	21.8%
Carex spp.	19.0 ± 17.3	25.8 ± 17.0	24.3	33.1	14.1	21.3	19.2	27.2
Typha latifolia	9.9 ± 8.8	7.4 ± 9.4	12.6	9.5	14.7	14.9	13.7	12.2
Sagittaria latifolia	6.0 ± 7.5	5.0 ± 9.6	7.7	6.4	10.3	5.3	9.0	5.9
Sparganium eurycarpum	6.0 ± 11.7	9.8 ± 18.7	7.7	12.5	7.1	6.4	7.4	9.5
Potentilla palustris	4.5 ± 7.6	8.3 ± 8.6	5.8	10.7	7.7	14.9	6.7	12.8
Lemna minor	3.8 ± 7.9	0.1 ± 0.3	4.9	0.1	6.4	2.1	5.6	1.1
Near-shore (shore to 45 m inland)		(N=15)						
Calla palustris		26.4 ± 23.8		36.3		15.2		25.7
Typha latifolia		12.4 ± 7.9		17.1		19.0		18.0
Spirodella polyrhiza		7.2 ± 8.0		9.9		13.9		11.9
Sparganium eurycarpum		9.1 ± 12.8		12.5		10.1		11.3
Carex spp.		9.1 ± 13.9		12.5		8.9		10.7
Sagittaria latifolia		4.7 ± 7.7		6.4		6.3		6.4
Shoreline (within 2 m open water)		(N=5)						
Sparagnium eurycarpum		44.0 ± 11.4		67.3		41.7		54.5
Sagittaria latifolia		21.0 ± 5.5		32.1		41.7		36.9
Typha latifolia		0.4 ± 0.5		0.6		16.7		8.7

[a] Vegetation with importance value ≥ 5%.
[b] In order of decreasing "importance".
[c] Importance value = $\frac{\text{relative frequency + relative cover}}{2}$.

Table G12. Dominant[a] Wetland Vegetation - Spirit Lake Point.

Species[b]	Mean % cover ± S.D. 1979	Mean % cover ± S.D. 1980	Relative cover 1979	Relative cover 1980	Relative frequency 1979	Relative frequency 1980	Importance[c] value 1979	Importance[c] value 1980
Overall (shore to 100 m inland)	(N=40)	(N=20)						
Carex spp.	45.0 ± 24.1%	48.5 ± 19.7%	63.3%	70.1%	31.7%	33.9%	47.5%	52.0%
Typha latifolia	5.0 ± 6.0	5.5 ± 6.1	7.0	8.0	16.7	19.6	11.9	13.8
Typha angustifolia	7.5 ± 14.2	6.0 ± 11.1	10.6	8.7	11.7	10.7	11.1	9.7
Sagittaria latifolia	3.7 ± 6.8	4.1 ± 6.6	5.1	5.9	10.0	14.3	7.6	10.1
Near-shore (shore to 45 m inland)		(N=15)						
Carex spp.		37.1 ± 22.2		58.0		26.0		42.0
Sagittaria latifolia		7.5 ± 8.1		12.0		21.0		16.2
Typha latifolia		5.7 ± 7.0		9.0		15.0		12.0
Calla palustris		2.2 ± 4.5		3.0		11.0		7.4
Myrica gale		5.3 ± 11.9		8.0		6.0		7.0
Shoreline (within 2 m open water)		(N=5)						
Carex spp.		36.0 ± 11.5		57.1		33.3		45.2
Typha latifolia		15.0 ± 5.0		23.0		33.3		28.6
Sagittaria latifolia		12.0 ± 5.7		19.1		33.3		26.2

[a] Vegetation with importance value ≥ 5%.
[b] In order of decreasing "importance".
[c] Importance value = $\frac{\text{relative frequency + relative cover}}{2}$.

Table G13. Dominant[a] Wetland Vegetation - Mike's Landing Culvert.

Species[b]	Mean % cover ± S.D. 1979	Mean % cover ± S.D. 1980	Relative cover 1979	Relative cover 1980	Relative frequency 1979	Relative frequency 1980	Importance[c] value 1979	Importance[c] value 1980
Overall	(N=10)							
Carex spp.	55.0 ± 19.2%		73.7%		30.3%		52.0%	
Glyceria spp.	12.9 ± 24.9		17.3		21.2		19.3	
Polygonum spp.	1.6 ± 3.1		2.1		15.2		8.7	
Scirpus spp.	0.9 ± 1.6		1.2		12.1		6.7	
Salix interior	3.5 ± 7.5		4.7		6.1		5.4	
Near-shore	No data							
Shoreline	No data							

[a]Vegetation with importance value $\geq$ 5%.
[b]In order of decreasing "importance".
[c]Importance value = $\frac{\text{relative frequency + relative cover}}{2}$.

Mike's Landing #2 (exposed to shipping)

This study plot lies 1.0 km southwest of Point Aux Frenes and approximately 2.0 km from the shipping lane. It is considered exposed to shipping although it is somewhat protected by a small point of land. The plot's orientation and this land mass protect it from direct wave action of passing ships to some extent. The marsh was similar to Mike's Landing Culvert and as such consisted of large sedge hummocks interspersed with a few small willow (Salix) and a few clumps of cattail (Typha) (Table G14). "Species" richess was moderate (14 taxa identified), but two genera, Carex and Glyceria, dominated. They comprised 45.2% and 35.0% of the marsh by relative cover respectively. Water depths were 25 cm or less. The only breeding bird recorded on this plot was the red-winged blackbird. It nested at a density of 93 territories/10 ha. No direct visible effects of shipping activity on this marsh area were observed.

Flory's Fortress (exposed to shipping)

This plot is 0.2 km northwest of Point Aux Frenes and is closer to the shipping lane (within 1.0 km) than any other study site in the St. Mary's River. It was dominated by dense stands of 1.5 to 2.0 m tall Typha (95.7% relative cover, Table G15). The cattails were present throughout the plot, but ended abruptly at the interface with a large band of detritus lying along the water's edge. Plant "species" richness on this plot was quite low (N=5 taxa). The only breeding bird recorded at this site was the red-winged blackbird. It had a territory density of 93 per 10 ha.

12-Mile Road #1, #2, #3 (exposed to shipping)

These three plots are located 150 m south of the diked portion at the end of 12 Mile Road. Since the plots are contiguous, they actually represent one large plot within this wetland. Both the winter (Middle Neebish) and summer (West Neebish) shipping lanes lie close to this wetland. Because the summer channel is only 0.5 km and the winter channel approximately 3.0 km to the east, summer impacts would appear to be more important.

Since the plots were contiguous, the overall vegetation present was similar. All three plots were dominated by sweetflag (Acorus calamus) and had moderate amounts of cattail (Typha)(Tables G16, 17, and 18). These two taxa co-dominated both plots #1 and #2, and thus these two plots were significantly *similar* ($=0.47$, $p=0.03$). Plots #3 was more diverse ("species" richness = 11) and thus not significantly similar to the other two plots. Generally, reeds (Scirpus) were present in the deeper water along the shore while cattail and sweetflag were found in the shallower water immediately inland. The sweetflag was most abundant in the shallowest quadrats (<50 cm deep).

Breeding bird populations within these plots were dominated by the red-winged blackbird. This was the only species recorded on plots #2 and #3. Plot #1 included the yellow warbler also. Territorial densities of the red-wings in 1979 were 80, 57, and 48 per 10 ha for plots #1, #2, and #3 respectively.

Table G14. Dominant[a] Wetland Vegetation - Mike's Landing Culvert Plot #2.

Species[b]	Mean % cover ± S.D.		Relative cover		Relative frequency		Importance[c] value	
	1979	1980	1979	1980	1979	1980	1979	1980
Overall	(N=10)							
Carex spp.	33.6 ± 22.3%		45.2%		23.3%		34.2%	
Glyceria spp.	26.0 ± 22.7		35.0		18.6		26.8	
Scutellaria spp.	2.1 ± 4.7		2.8		9.3		6.1	
Phragmites communis	0.5 ± 0.7		0.7		4.7		5.0	
Salix spp.	4.0 ± 8.7		5.4		4.7		5.0	
Near-shore	No data							
Shoreline	No data							

[a]Vegetation with importance value $\geq$ 5%.
[b]In order of decreasing "importance".
[c]Importance value = $\frac{\text{relative frequency + relative cover}}{2}$.

Table G15. Dominant[a] Wetland Vegetation - Flory's Fortress.

Species[b]	Mean % cover ± S.D.		Relative cover		Relative frequency		Importance[c] value	
	1979	1980	1979	1980	1979	1980	1979	1980
Overall								
Typha augustifolia	20.0 ± 12.5%		95.7%		71.4%		83.6%	
Carex spp.	0.5 ± 1.6		2.4		7.1		4.8	
Sagittaria latifolia	0.2 ± 0.6		1.0		7.1		4.1	
Sparganium eurycarpum	0.1 ± 0.3		0.5		7.1		3.8	
Eupatorium purpureum	0.1 ± 0.3		0.5		7.1		3.8	
Near-shore	No data							
Shoreline	No data							

[a] Vegetation with importance value $\geq$ 5%.
[b] In order of decreasing "importance".
[c] Importance value = $\frac{\text{relative frequency + relative cover}}{2}$.

Table G16. Dominant[a] Wetland Vegetation - 12-mile Road Plot #1.

Species[b]	Mean % cover ± S.D. 1979	Mean % cover ± S.D. 1980	Relative cover 1979	Relative cover 1980	Relative frequency 1979	Relative frequency 1980	Importance[c] value 1979	Importance[c] value 1980
Overall	(N=10)	(N=10)						
Typha latifolia	8.1 ± 10.0%	2.3 ± 4.1%	34%	21%	28%	13%	31%	17%
Acorus calamus	11.5 ± 16.2	4.5 ± 10.1	48	16	16	6	32	11
Equisetum spp.	1.2 ± 2.1	2.7 ± 4.6	5	10	12	16	9	13
Typha angustifolia	1.3 ± 2.2	5.7 ± 7.8	5	10	12	9	9	9
Carex spp.	0.5 ± 1.6	4.0 ± 5.3	2	15	4	13	3	4
Scripus spp.	0.6 ± 1.1	1.9 ± 3.5	2	7	12	9	7	8
Sagittaria latifolia	0.2 ± 0.4	0.9 ± 1.3	1	3	8	13	5	8
Glyceria spp.	0.2 ± 0.6	1.1 ± 1.9	1	7	4	13	3	10
Near-shore	No data							
Shoreline (within 2 m open water)		(N=5)						
Typha angustifolia		6.6 ± 6.3		54.1		30.0		42.1
Acorus calamus		3.0 ± 6.7		24.6		10.0		17.3
Scirpus spp.		1.2 ± 2.2		9.8		20.0		14.9
Sagittaria latifolia		0.8 ± 1.3		6.6		20.0		13.3
Equisetum spp.		0.6 ± 0.9		4.9		20.0		12.5

[a]Vegetation with importance value $\geq$ 5%.
[b]In order of decreasing "importance".
[c]Importance value = $\frac{\text{relative frequency + relative cover}}{2}$.

Table G17. Dominant[a] Wetland Vegetation - 12-mile Road Plot #2.

Species[b]	Mean % cover ± S.D. 1979	Mean % cover ± S.D. 1980	Relative cover 1979	Relative cover 1980	Relative frequency 1979	Relative frequency 1980	Importance[c] value 1979	Importance[c] value 1980
Overall	(N=10)							
Acorus calamus	19.0 ± 20.4%		75%		22%		49%	
Typha latifolia	3.7 ± 6.5		14		26		20	
Scirpus spp.	1.3 ± 3.1		5		17		11	
Equisetum spp.	0.7 ± 1.0		3		17		10	
Typha angustifolia	0.5 ± 0.8		2		9		6	
Glyceria spp.	0.7 ± 1.0		1		9		5	
Near-shore	No data							
Shoreline	No data							

[a]Vegetation with importance value $\geq$ 5%.
[b]In order of decreasing "importance".
[c]Importance value = $\frac{\text{relative frequency + relative cover}}{2}$.

Table G18. Dominant[a] Wetland Vegetation - 12-mile Road Plot #3.

Species[b]	Mean % cover ± S.D.		Relative cover		Relative frequency		Importance[c] value	
	1979	1980	1979	1980	1979	1980	1979	1980
Overall	(N=10)							
Acorus calamus	9.7 ± 17.0%		54%		36%		45%	
Scirpus spp.	3.8 ± 4.3		21		36		28	
Typha latifolia	3.0 ± 9.5		17		7		12	
Typha angustifolia	1.5 ± 3.4		8		14		11	
Near-shore	No data							
Shoreline	No data							

[a]Vegetation with importance value ≥ 5%.
[b]In order of decreasing "importance".
[c]Importance value = $\frac{\text{relative frequency + relative cover}}{2}$.

Only plot #1 was censused in 1980, and red-wing density was appreciably lower that year (40 per 10 ha).

Visible effects of shipping activity were not evident. However, the extensive Scirpus present in the deeper shoreline zone may indicate repeated scouring of organic matter from the bottom, resulting in the dominance by the more stable reeds. If shipping has had an effect on this wetland, it is difficult to ascertain whether summer or winter activity has been responsible. Summer traffic would seem the more likely agent due to the proximity of the West Neebish Channel.

9 Mile Road #1 and #2 (exposed to shipping)

These plots are located at the end of 9 Mile Road. Plot #1 lies 10 m south of the road dike and plot #2 250 m north of the parking area. The shipping lane, used both winter and summer, lies only 1 km to the east, and thus these sites are considered exposed or adjacent to shipping activity.

The vegetation within this wetland was distinctly banded although, as indicated by differences between the two plots, not uniformly so (Tables G19 and 20). Plot #2 showed definite changes in plant abundance with distance from shore. The shoreline was dominated by Scirpus, Eleocharis, and Equisetum, but these gave way to Typha and eventually Carex in the shallower inland areas. Plot #1 showed a similar pattern, but the shoreline was predominantly Typha. Water depths ranged from 1.5 m at shoreline to only 10 cm in the interior portions.

Nesting activity was only documented on plot #1, and this only during 1980. The only breeding birds recorded were the red-winged blackbird and the swamp sparrow. They nested in densities of 52 and 20 territories per 10 ha respectively.

No obvious effect of shipping activity was evident, although, as noted regarding the 12 Mile Road wetland, the extensive Scirpus present in some shoreline areas may indicate repeated scouring due to ship passage.

Whitehouse #1, #2, and #3 (unexposed to shipping)

These three contiguous plots are located 1 km south of Fowler's Bay in Lake Munuscong (Figure 30) and are approximately 6 km from the shipping lane. In addition to their distance from shipping activity, they are further protected since they lie at the base of a small bay. Thus these plots are considered remote or unexposed to shipping activity.

The shoreline of this wetland was dominated by cattail, (Typha) but this graded into Carex hummocks interspersed with a few willow in the interior portions. Overall, the area was predominantly Carex as this genus comprised 64, 89, and 69 percent by relative cover of plots #1, #2, and #3 respectively (Tables G21, 22, and 23). Typha was dominant only in the near-shore areas. Species richness was moderate and ranged from 7 to 9 on the three plots. Water depths varied from 1.0 m at the shoreline to less than 10 cm in the innermost portions of the plot.

Table G19. Dominant[a] Wetland Vegetation - 9-mile Road Plot #1.

Species[b]	Mean % cover ± S.D. 1979	Mean % cover ± S.D. 1980	Relative cover 1979	Relative cover 1980	Relative frequency 1979	Relative frequency 1980	Importance[c] value 1979	Importance[c] value 1980
Overall	No data							
Near-shore (shore to 45 m inland)		(N=15)						
Typha angustifolia		13.6 ± 16.4%		55%		27%		40%
Carex spp.		6.0 ± 5.1		24		25		24
Eleocharis spp.		2.6 ± 2.5		11		20		16
Scirpus spp.		1.4 ± 2.0		6		14		10
Glyceria spp.		0.7 ± 1.6		3		6		5
Shoreline (within 2 m open water)		(N=5)						
Typha angustifolia		44.6 ± 8.4		86.1		41.7		63.9
Scirpus spp.		6.4 ± 2.2		12.4		41.7		27.0
Equisetum spp.		0.8 ± 1.1		1.5		16.7		9.1

[a]Vegetation with importance value ≥ 5%.
[b]In order of decreasing "importance".
[c]Importance value = $\frac{\text{relative frequency + relative cover}}{2}$.

Table G20. Dominant[a] Wetland Vegetation - 9-mile Road Plot #2.

Species[b]	Mean % cover ± S.D. 1979	Mean % cover ± S.D. 1980	Relative cover 1979	Relative cover 1980	Relative frequency 1979	Relative frequency 1980	Importance[c] value 1979	Importance[c] value 1980
Overall	No data							
Near-shore (shore to 45 m inland)		(N=15)						
Typha angustifolia		14.7 ± 12.7%		35%		19%		27%
Carex spp.		13.8 ± 11.3		33		16		24
Scirpus spp.		3.4 ± 2.9		8		17		13
Equisetum spp.		3.3 ± 4.6		8		14		11
Typha latifolia		2.5 ± 5.2		6		5		5
Glyceria spp.		1.0 ± 2.6		2		8		5
Sium suave		0.9 ± 1.8		2		8		5
Shoreline (within 2 m open water)		(N=5)						
Eleocharis spp.		11.6 ± 4.8		34.9		33.3		34.1
Equisetum spp.		11.0 ± 5.5		33.1		33.3		33.2
Scirpus spp.		10.6 ± 2.6		31.9		33.3		32.6

[a] Vegetation with importance value $\geq$ 5%.
[b] In order of decreasing "importance".
[c] Importance value = $\frac{\text{relative frequency + relative cover}}{2}$.

Table G21. Dominant[a] Wetland Vegetation - Whitehouse Plot #1.

Species[b]	Mean % cover ± S.D. 1979	Mean % cover ± S.D. 1980	Relative cover 1979	Relative cover 1980	Relative frequency 1979	Relative frequency 1980	Importance[c] value 1979	Importance[c] value 1980
Overall	(N=10)							
Carex spp.	33.7 ± 18.8%	72.5 ± 17.0%	63.7%	88.9%	35.7%	45.5%	49.7%	67.2%
Glyceria spp.	5.3 ± 7.4	4.6 ± 6.8	10.0	5.6	28.6	22.7	19.3	14.2
Polygonum spp.	0.2 ± 0.6	1.6 ± 4.7	0.4	2.0	3.6	9.1	2.0	5.5
Near-shore	No data							
Shoreline (within 2 m open water)		(N=5)						
Typha latifolia		39.0 ± 4.2		89.5		45.5		67.5
Sagittaria latifolia		3.6 ± 2.1		8.3		36.4		22.3
Sparganium eurycarpum		1.0 ± 1.7		2.3		18.2		10.2

[a]Vegetation with importance value ≥ 5%.
[b]In order of decreasing "importance".
[c]Importance value = $\frac{\text{relative frequency + relative cover}}{2}$.

Table G22. Dominant[a] Wetland Vegetation - Whitehouse Plot #2.

Species[b]	Mean % cover ± S.D.		Relative cover		Relative frequency		Importance[c] value	
	1979	1980	1979	1980	1979	1980	1979	1980
Overall	(N=10)							
Carex spp.	56.2 ± 23.2%		89%		33%		61%	
Phalaris arundinaceae	3.8 ± 4.3		6		20		13	
Glyceria spp.	1.0 ± 0.9		1		20		11	
Polygonum spp.	1.9 ± 3.3		3		17		10	
Near-shore	No data							
Shoreline	No data							

[a] Vegetation with importance value $\geq$ 5%.
[b] In order of decreasing "importance".
[c] Importance value = $\frac{\text{relative frequency + relative cover}}{2}$.

Table G23. Dominant[a] Wetland Vegetation - Whitehouse Plot #3.

Species[b]	Mean % cover ± S.D. 1979	Mean % cover ± S.D. 1980	Relative cover 1979	Relative cover 1980	Relative frequency 1979	Relative frequency 1980	Importance[c] value 1979	Importance[c] value 1980
Overall								
Carex spp.	70.6 ± 12.6%		69%		35%		52%	
Phalaris arundinaceae	28.0 ± 26.2		27		24		26	
Glyceria spp.	1.9 ± 3.3		2		14		8	
Typha latifolia	0.3 ± 0.5		+		10		5	
Near-shore	No data							
Shoreline	No data							

[a]Vegetation with importance value $\geq$ 5%.
[b]In order of decreasing "importance".
[c]Importance value = $\frac{\text{relative frequency + relative cover}}{2}$.

The dominant breeding bird was the red-winged blackbird. This was the only species recorded on plots #2 and #3 and was predominant on plot #1, although two additional species, the swamp sparrow and long-billed marsh wren were present in low numbers on the latter site also. There appeared to be a large change in breeding density between 1979 and 1980 on plot #1, the only one studied both years. Territory density of the red-winged blackbird nearly tripled from 72 to 196 per 10 ha. Swamp sparrow numbers similarly increased from 9.0 to 20 territories per 10 ha. Despite the apparent high breeding density in 1980, only a single red-wing nest was found.

Munuscong Dike #1, #2, and #3 (unexposed to shipping)

These plots, although not contiguous, all are part of a single wetland which lies within the Michigan DNR waterfowl habitat dikes area. This area is located on the south side of the mouth of Munuscong River at Lake Munuscong The shipping lane is approximately 8 km to the east of this site, and this distance in conjunction with the dike structure effectively isolate these plots from direct shipping impact. The presence of the dike does present an artificial situation and complicates interpretation of the results.

The wetland is fairly homogeneous, and this is evident in the fact that plots #2 and #3 had a high index of similarity ($r=0.48$, Tables G24, 25 and 26). Plot #1 appeared somewhat different than the latter two ($r = -0.12$, $r = -0.13$). This is primarily due to the presence of Scirpus on plot #1. Overall, Carex was the dominant genus, and it comprised from 32% to 77% by relative cover of the plots. Scirpus co-dominated on plot #1. Species richness was moderate (from 9 to 10 taxa present). No zonation was apparent and this is probably due to the lack of exposure to open water (dike effect). Water depths varied from 50 cm to 2 m. Clumps of cattails were present in some of the deeper areas.

The dominant breeding bird was the red-winged blackbird. However, both swamp sparrows and yellow warblers were present also, and, on plot #3 both were more abundant than red-wings.

Kemp's Point Cove (unexposed to shipping)

This marsh is located along the north edge of Lake Munuscong and on the east side of Kemp's Point. Since Kemp's Point lies between it and the shipping lane, this site is effectively isolated from direct effects of shipping activity.

The vegetation was distinctly banded. The shoreline was predominantly Eleocharis and Scirpus, the near-shore area cattail (Typha) and sedge (Carex) and the innermost portions almost exclusively sedge (Table G27). This was the only "remote" marsh studied which had large amounts of detritus present along the shoreline. Water depths ranged from 50 cm to 1.0 m.

Breeding bird use of the plot was limited to red-winged blackbirds and long-billed marsh wrens. Territory densities were 90 per 10 ha for the former and 10 per 10 ha for the latter.

Table G24. Dominant[a] Wetland Vegetation - Munuscong Dike Plot #1.

Species[b]	Mean % cover ± S.D.		Relative cover		Relative frequency		Importance[c] value	
	1979	1980	1979	1980	1979	1980	1979	1980
Overall	(N=10)							
Carex spp.	13.6 ± 11.7%		32%		18%		25%	
Scirpus spp.	11.5 ± 12.5		27		14		21	
Juncus spp.	3.7 ± 3.7		9		18		14	
Equisetum spp.	1.2 ± 0.9		3		16		10	
Typha angustifolia	4.2 ± 7.3		10		8		9	
Salix interior	5.1 ± 10.8		12		6		9	
Potentilla palustris	1.3 ± 2.0		3		10		7	
Near-shore	No data							
Shoreline	No data							

[a]Vegetation with importance value $\geq$ 5%.
[b]In order of decreasing "importance".
[c]Importance value = $\frac{\text{relative frequency + relative cover}}{2}$.

Table G25. Dominant[a] Wetland Vegetation - Munuscong Dike Plot #2.

Species[b]	Mean % cover ± S.D. 1979	Mean % cover ± S.D. 1980	Relative cover 1979	Relative cover 1980	Relative frequency 1979	Relative frequency 1980	Importance[c] value 1979	Importance[c] value 1980
Overall	(N=10)							
Carex spp.	34.5 ± 15.5%		77%		29%		53%	
Glyceria spp.	3.0 ± 3.3		7		18		13	
Typha latifolia	5.1 ± 7.0		9		12		11	
Juncus spp.	1.5 ± 2.4		3		9		6	
Salix interior	0.4 ± 0.7		1		9		5	
Near-shore	No data							
Shoreline	No data							

[a]Vegetation with importance value $\geq$ 5%.
[b]In order of decreasing "importance".
[c]Importance value = $\frac{\text{relative frequency + relative cover}}{2}$.

Redhouse (unexposed to shipping)

This plot is located near the Whitehouse plots, but on the southwest facing shore of the small bay involved. The nearest shipping lane is more than 5 km to the east. This coupled with the orientation of the bay effectively isolates this plot from shipping activity.

Although "species" richness was moderate (N=8 taxa), the site was almost completely dominated by sedge (84% by relative cover) (Table G28). There was a narrow band of cattail on the shoreline. Water depth varied from 50 cm to 1.0 m.

In contrast to most plots, the predominant breeding bird on this one was the swamp sparrow (66 territories per 10 ha). The red-winged blackbird was sparse (6.0 terr. per 10 ha). This site also was the only one to include savannah sparrows.

Table G26. Dominant[a] Wetland Vegetation - Munuscong Dike Plot #3.

Species[b]	Mean % cover ± S.D.		Relative cover		Relative frequency		Importance[c] value	
	1979	1980	1979	1980	1979	1980	1979	1980
Overall	(N=10)							
Carex spp.	20.0 ± 11.2%		63%		26%		42%	
Typha latifolia	3.9 ± 2.4		12		21		16	
Juncus spp.	2.8 ± 3.5		9		13		11	
Equisetum spp.	0.6 ± 0.7		4		13		9	
Potentilla palustris	0.5 ± 0.9		2		8		5	
Near-shore	No data							
Shoreline	No data							

[a]Vegetation with importance value $\geq$ 5%.
[b]In order of decreasing "importance".
[c]Importance value = $\frac{\text{relative frequency + relative cover}}{2}$.

Table G27. Dominant[a] Wetland Vegetation - Kemp's Point.

Species[b]	Mean % cover ± S.D. 1979	Mean % cover ± S.D. 1980	Relative cover 1979	Relative cover 1980	Relative frequency 1979	Relative frequency 1980	Importance[c] value 1979	Importance[c] value 1980
Overall	No data							
Near-shore (shore to 45 m inland)								
Carex spp.		24.7 ± 6.7%		59%		27%		42%
Glyceria spp.		4.2 ± 4.1		10		20		15
Typha latifolia		7.7 ± 11.8		18		11		14
Polygonum spp.		0.9 ± 2.6		2		9		6
Impatiens capensis		1.4 ± 2.9		3		9		6
Shoreline (within 2 m open water)								
Eleocharis spp.		23.0 ± 6.7%		50.7		21.7		36.2
Scirpus validus		12.6 ± 4.9		27.8		21.7		24.8
Sagittaria latifolia		4.2 ± 3.5		9.3		21.7		15.5
Carex spp.		4.0 ± 1.7		8.8		21.7		15.3
Typha latifolia		1.4 ± 2.2		3.1		8.7		5.9

[a]Vegetatior with importance value ≥ 5%.
[b]In order of decreasing "importance".
[c]Importance value = $\frac{\text{relative frequency + relative cover}}{2}$.

Table G28. Dominant[a] Wetland Vegetation - Redhouse Plot.

Species[b]	Mean % cover ± S.D. 1979	Mean % cover ± S.D. 1980	Relative cover 1979	Relative cover 1980	Relative frequency 1979	Relative frequency 1980	Importance[c] value 1979	Importance[c] value 1980
Overall	No data							
Near-shore (shore to 45 m inland)		(N=15)						
Carex spp.		62.3 ± 18.4%		84%		27%		56%
Glyceria spp.		3.5 ± 3.3		5		22		14
Galium trifidum		3.7 ± 1.9		5		20		13
Impatiens capensis		0.7 ± 1.4		1		9		5
Polygonum spp.		1.1 ± 1.9		2		7		5
Shoreline (within 2 m open water)		(N=5)						
Typha latifolia		25.0 ± 7.1		53.7		25.0		39.3
Potentilla palustris		7.0 ± 6.7		15.0		15.0		15.0
Acorus calamus		7.0 ± 6.7		15.0		15.0		15.0
Sparganium eurycarpum		3.0 ± 4.0		6.4		20.0		13.2
Polygonum spp.		3.2 ± 4.3		6.9		15.0		10.9

[a] Vegetation with importance value $\geq$ 5%.
[b] In order of decreasing "importance".
[c] Importance value = $\frac{\text{relative frequency + relative cover}}{2}$.

APPENDIX H. SUMMARIES OF VEGETATION ANALYSIS AT COLONIAL BIRD NESTING SITES ON THE ST. MARY'S RIVER, 1979-80

Table H1. Summary of Woody Vegetation, Southwest Neebish Island #3 - 1979.

Species	Vegetation parameters[a]				
	Relative density	Standard deviation	Relative frequency	Relative % cover	Importance value
Salix interior	0.74	6.36	0.33	0.83	1.90
Rubus sp.	0.18	13.42	0.17	0.07	0.42
Sambucus pubens	0.03	2.12	0.17	0.04	0.24
Cornus stolonifera	0.05	0.71	0.33	0.06	0.44

[a]Relative density = $\frac{\text{density for species}}{\text{total density for all species}}$

Density = $\frac{\text{number individuals}}{\text{area sampled}}$

Relative frequency = $\frac{\text{frequency for species}}{\text{total frequency values for all species}}$

Frequency = $\frac{\text{number of plots species occurred}}{\text{total number of plots}}$

% cover = % of sample area covered by given species

Re'ative % of cover = $\frac{\text{\% cover for species}}{\text{total \% cover for all species}}$

Importance value = relative density + relative % cover + relative frequency

Table H2. Summary of Woody Vegetation, Southwest Neebish Island #2 - 1979.

Species	Vegetation parameters[a]				
	Relative density	Standard deviation	Relative frequency	Relative % cover	Importance value
Salix interior	0.83	22.41	0.50	0.66	1.99
Sambucus pubens	0.17	4.24	0.50	0.34	1.01

[a]Relative density = $\frac{\text{density for species}}{\text{total density for all species}}$

Density = $\frac{\text{number individuals}}{\text{area sampled}}$

Relative frequency = $\frac{\text{frequency for species}}{\text{total frequency values for all species}}$

Frequency = $\frac{\text{number of plots species occurred}}{\text{total number of plots}}$

% cover = % of sample area covered by given species

Relative % of cover = $\frac{\text{\% cover for species}}{\text{total \% cover for all species}}$

Importance value = relative density + relative % cover + relative frequency

Table H3. Summary of Woody Vegetation, Moon Island - 1979.

Species	Vegetation parameters[a]				
	Relative density	Standard deviation	Relative frequency	Relative % cover	Importance value
Salix amygdaloides	0.05	1.79	0.13	0.17	0.35
Populus tremuloides	0.04	0.89	0.25	0.24	0.53
Sambucus pubens	0.03	0.89	0.13	0.07	0.23
Salix interior	0.75	11.11	0.38	0.38	1.51
Cornus stolonifera	0.14	4.92	0.13	0.14	0.41

[a]Relative density = $\frac{\text{density for species}}{\text{total density for all species}}$

Density = $\frac{\text{number individuals}}{\text{area sampled}}$

Relative frequency = $\frac{\text{frequency for species}}{\text{total frequency values for all species}}$

Frequency = $\frac{\text{number of plots species occurred}}{\text{total number of plots}}$

% cover = % of sample area covered by given species

Relative % of cover = $\frac{\text{\% cover for species}}{\text{total \% cover for all species}}$

Importance value = relative density + relative % cover + relative frequency

Table H4. Summary of Woody Vegetation, Steamboat Island - 1979.

Species	Vegetation parameters[a]				
	Relative density	Standard deviation	Relative frequency	Relative % cover	Importance value
Cornus stolonifera	0.70	13.80	0.33	0.68	1.71
Populus tremuloides	0.06	1.73	0.25	0.09	0.40
Rubus sp.	0.15	7.00	0.08	0.06	0.29
Sambucus pubens	0.08	1.82	0.25	0.14	0.47
Amelanchier humilis	0.01	0.50	0.08	0.03	0.12

[a]Relative density = $\frac{\text{density for species}}{\text{total density for all species}}$

Density = $\frac{\text{number individuals}}{\text{area sampled}}$

Relative frequency = $\frac{\text{frequency for species}}{\text{total frequency values for all species}}$

Frequency = $\frac{\text{number of plots species occurred}}{\text{total number of plots}}$

% cover = % of sample area covered by given species

Relative % of cover = $\frac{\text{\% cover for species}}{\text{total \% cover for all species}}$

Importance value = relative density + relative % cover + relative frequency

Table H5. Summary of Herbaceous Vegetation, Northwest Sugar Island - 1980.

Species	Vegetation parameters[a]				
	Relative density	Standard deviation	Relative frequency	Relative % cover	Importance value
Equisetum sp.	0.24	3.61	0.17	0.63	1.04
Cirsium arvense	0.15	3.20	0.17	0.06	0.38
Solidago sp.	0.20	10.67	0.17	0.12	0.49
Taraxacum officinale	0.12	2.45	0.17	0.05	0.34
Poa pratensis	0.24	5.92	0.17	0.04	0.45
Barbarea vulgaris	0.02	1.26	0.13	0.08	0.23
Glyceria grandis	0.02	2.50	0.04	0.01	0.07

[a]Relative density = $\frac{\text{density for species}}{\text{total density for all species}}$

Density = $\frac{\text{number individuals}}{\text{area sampled}}$

Relative frequency = $\frac{\text{frequency for species}}{\text{total frequency values for all species}}$

Frequency = $\frac{\text{number of plots species occurred}}{\text{total number of plots}}$

% cover = % of sample area covered by given species

Relative % of cover = $\frac{\text{\% cover for species}}{\text{total \% cover for all species}}$

Importance value = relative density + relative % cover + relative frequency

Table H6. Summary of Herbaceous Vegetation, Upper Nicolet Island #1 - 1979.

	Vegetation parameters				
	d				
Latuca canadensis	0.01	1.63	2.63	0.00	2.64
Potentilla recta					
Urtica dioica	0.17	38.58	0.05	0.09	0.31
Glyceria sp.	0.04	6.97	0.05	0.02	0.11
Impatiens capensis	0.46	46.11	0.16	0.26	0.88
Barbarea vulgaris	0.04	7.99	0.08	0.16	0.28
Solanum dulcamara	0.05	9.61	0.05	0.10	0.20
Linaria vulgaris	0.02	6.12	0.03	0.02	0.07
Bromus tectorum	0.01	1.63	0.03	0.02	0.06
Salix interior	0.02	6.12	0.03	0.02	0.07
Salix amydaloides	0.00	0.41	0.03	0.02	0.05
Hieracium aurantiacum	0.01	2.45	0.03	0.02	0.06
Chrysanthemum leucanthemum	0.05	12.98	0.05	0.06	0.16
Oenothera biennis	0.00	0.41	0.03	0.00	0.03
Hypericum perforatum	0.02	6.12	0.03	0.04	0.09

Table H6 (concluded).

Species	Vegetation parameters[a]				
	Relative density	Standard deviation	Relative frequency	Relative % cover	Importance value
Phleum pratense	0.01	1.63	0.03	0.00	0.04
Solidago sp.	0.05	8.04	0.08	0.08	0.21
Rumex mexicanus	0.01	2.40	0.05	0.03	0.09
Taraxacum officinale	0.00	0.52	0.05	0.01	0.06
Cirsium arvense	0.00	0.41	0.03	0.00	0.03
Stellaria media	0.03	4.32	0.05	0.03	0.11

[a]Relative density = $\frac{\text{density for species}}{\text{total density for all species}}$

Density = $\frac{\text{number individuals}}{\text{area sampled}}$

Relative frequency = $\frac{\text{frequency for species}}{\text{total frequency values for all species}}$

Frequency = $\frac{\text{number of plots species occurred}}{\text{total number of plots}}$

% cover = % of sample area covered by given species

Relative % of cover = $\frac{\text{\% cover for species}}{\text{total \% cover for all species}}$

Importance value = relative density + relative % cover + relative frequency

Table H7. Summary of Herbaceous Vegetation, West Pipe Twin Island - 1980.

Species	Vegetation parameters[a]				
	Relative density	Standard deviation	Relative frequency	Relative % cover	Importance value
Impatiens capensis	0.59	29.27	0.25	0.19	1.03
Urtica dioica	0.09	8.78	0.13	0.09	0.31
Polygonum sp.	0.02	2.00	0.04	0.01	0.07
Barbarea vulgaris	0.04	3.16	0.08	0.05	0.17
Pastinaca sativa	0.01	1.09	0.12	0.03	0.16
Equisetum	0.01	1.00	0.04	0.01	0.06
Sambucus canadensis	0.08	4.59	0.21	0.40	0.69
Solidago sp.	0.15	10.18	0.12	0.22	0.49

[a]Relative density = $\frac{\text{density for species}}{\text{total density for all species}}$

Density = $\frac{\text{number individuals}}{\text{area sampled}}$

Relative frequency = $\frac{\text{frequency for species}}{\text{total frequency values for all species}}$

Frequency = $\frac{\text{number of plots species occurred}}{\text{total number of plots}}$

% cover = % of sample area covered by given species

Relative % of cover = $\frac{\text{\% cover for species}}{\text{total \% cover for all species}}$

Importance value = relative density + relative % cover + relative frequency

Table H8. Summary of Herbaceous Vegetation, Southwest Neebish Island #2a - 1979.

Species	Vegetation parameters[a]				
	Relative density	Standard deviation	Relative frequency	Relative % cover	Importance value
Phragmites communis	0.98	23.74	0.71	0.97	2.66
Heracleum maximum	0.02	1.49	0.29	0.03	0.34

[a]Relative density = $\dfrac{\text{density for species}}{\text{total density for all species}}$

Density = $\dfrac{\text{number individuals}}{\text{area sampled}}$

Relative frequency = $\dfrac{\text{frequency for species}}{\text{total frequency values for all species}}$

Frequency = $\dfrac{\text{number of plots species occurred}}{\text{total number of plots}}$

% cover = % of sample area covered by given species

Relative % of cover = $\dfrac{\text{\% cover for species}}{\text{total \% cover for all species}}$

Importance value = relative density + relative % cover + relative frequency

Table H9. Summary of Herbaceous Vegetation, Southwest Neebish Island #1 - 1979.

Species	Vegetation parameters[a]				
	Relative density	Standard deviation	Relative frequency	Relative % cover	Importance value
Phragmites communis	0.83	14.58	0.53	0.75	2.11
Urtica diocia	0.17	7.36	0.47	0.25	0.89

[a]Relative density = $\frac{\text{density for species}}{\text{total density for all species}}$

Density = $\frac{\text{number individuals}}{\text{area sampled}}$

Relative frequency = $\frac{\text{frequency for species}}{\text{total frequency values for all species}}$

Frequency = $\frac{\text{number of plots species occurred}}{\text{total number of plots}}$

% cover = % of sample area covered by given species

Relative % of cover = $\frac{\text{\% cover for species}}{\text{total \% cover for all species}}$

Importance value = relative density + relative % cover + relative frequency

Table H10. Summary of Herbaceous Vegetation, Southwest Neebish Island #2b - 1979.

Species	Vegetation parameters[a]				
	Relative density	Standard deviation	Relative frequency	Relative % cover	Importance value
Phragmites communis	0.16	2.91	0.38	0.28	0.82
Bromus tectorum	0.71	12.03	0.38	0.49	1.58
Urtica diocia	0.13	3.46	0.25	0.23	0.61

[a]Relative density = $\frac{\text{density for species}}{\text{total density for all species}}$

Density = $\frac{\text{number individuals}}{\text{area sampled}}$

Relative frequency = $\frac{\text{frequency for species}}{\text{total frequency values for all species}}$

Frequency = $\frac{\text{number of plots species occurred}}{\text{total number of plots}}$

% cover = % of sample area covered by given species

Relative % of cover = $\frac{\text{\% cover for species}}{\text{total \% cover for all species}}$

Importance value = relative density + relative % cover + relative frequency

Table H11. Summary of Herbaceous Vegetation, Southwest Neebish Island - 1980.

Species	Vegetation parameters[a]				
	Relative density	Standard deviation	Relative frequency	Relative % cover	Importance value
Urtica diocia	0.00	0.67	0.11	0.02	0.13
Bromus sp.	0.99	112.43	0.78	0.95	2.72
Barbarea vulgaris	0.00	1.00	0.11	0.02	0.13

[a]Relative density = $\frac{\text{density for species}}{\text{total density for all species}}$

Density = $\frac{\text{number individuals}}{\text{area sampled}}$

Relative frequency = $\frac{\text{frequency for species}}{\text{total frequency values for all species}}$

Frequency = $\frac{\text{number of plots species occurred}}{\text{total number of plots}}$

% cover = % of sample area covered by given species

Relative % of cover = $\frac{\text{\% cover for species}}{\text{total \% cover for all species}}$

Importance value = relative density + relative % cover + relative frequency

Table H12. Summary of Herbaceous Vegetation, Southeast Neebish Island - 1979.

Species	Vegetation parameters[a]				
	Relative density	Standard deviation	Relative frequency	Relative % cover	Importance value
Poa pratensis	0.95	805.42	0.24	0.93	2.12
Trifolium agrarium	0.00	16.55	0.10	0.02	0.12
Chrysanthemum leucanthemum	0.00	9.39	0.10	0.01	0.11
Agrupyron repens	0.04	51.45	0.38	0.03	0.45
Barbarea vulgaris	0.01	37.97	0.10	0.01	0.12
Cirsium arvense	0.00	0.45	0.10	0.00	0.10

[a]Relative density = $\frac{\text{density for species}}{\text{total density for all species}}$

Density = $\frac{\text{number individuals}}{\text{area sampled}}$

Relative frequency = $\frac{\text{frequency for species}}{\text{total frequency values for all species}}$

Frequency = $\frac{\text{number of plots species occurred}}{\text{total number of plots}}$

% cover = % of sample area covered by given species

Relative % of cover = $\frac{\text{\% cover for species}}{\text{total \% cover for all species}}$

Importance value = relative density + relative % cover + relative frequency

Table H13. Summary of Herbaceous Vegetation, Moon Island - 1979.

Species	Vegetation parameters[a]				
	Relative density	Standard deviation	Relative frequency	Relative % cover	Importance value
Phragmites communis	0.89	22.47	0.67	0.92	2.48
Agropyron repens	0.01	1.56	0.04	0.02	0.07
Chenopodium album	0.06	3.70	0.15	0.03	0.24
Poa pratensis	0.01	1.34	0.04	0.01	0.06
Capsella bursa-pastoris	0.03	3.13	0.07	0.01	0.11
Melilotus alba	0.00	0.22	0.04	0.01	0.05

[a] $\text{Relative density} = \dfrac{\text{density for species}}{\text{total density for all species}}$

$\text{Density} = \dfrac{\text{number individuals}}{\text{area sampled}}$

$\text{Relative frequency} = \dfrac{\text{frequency for species}}{\text{total frequency values for all species}}$

$\text{Frequency} = \dfrac{\text{number of plots species occurred}}{\text{total number of plots}}$

% cover = % of sample area covered by given species

$\text{Relative \% of cover} = \dfrac{\text{\% cover for species}}{\text{total \% cover for all species}}$

Importance value = relative density + relative % cover + relative frequency

Table H14. Summary of Herbaceous Vegetation, Southwest Neebish Island - 1980.

Species	Vegetation parameters[a]				
	Relative density	Standard deviation	Relative frequency	Relative % cover	Importance value
Barbarea vulgaris	0.00	0.52	0.04	0.01	0.05
Urtica dioica	0.10	14.88	0.13	0.17	0.40
Agropyron sp.	0.05	11.36	0.04	0.01	0.10
Salix interior	0.13	11.50	0.26	0.12	0.51
Matricaria matricarioides	0.21	24.06	0.26	0.23	0.70
Polygonum sp.	0.51	54.33	0.22	0.46	1.19
Phragmites communis	0.00	0.52	0.04	0.01	0.05

[a]Relative density = $\frac{\text{density for species}}{\text{total density for all species}}$

Density = $\frac{\text{number individuals}}{\text{area sampled}}$

Relative frequency = $\frac{\text{frequency for species}}{\text{total frequency values for all species}}$

Frequency = $\frac{\text{number of plots species occurred}}{\text{total number of plots}}$

% cover = % of sample area covered by given species

Relative % of cover = $\frac{\text{\% cover for species}}{\text{total \% cover for all species}}$

Importance value = relative density + relative % cover + relative frequency

Table H15. Summary of Herbaceous Vegetation, Moon Island - 1980.

Species	Vegetation parameters[a]				
	Relative density	Standard deviation	Relative frequency	Relative % cover	Importance value
Phragmites communis	0.32	31.31	0.34	0.49	1.15
Agropyron	0.45	61.92	0.31	0.22	0.98
Poa sp.	0.14	45.80	0.02	0.01	0.17
Chenopodium album	0.05	7.78	0.17	0.22	0.44
Capsella bursa-pastoris	0.01	2.01	0.02	0.00	0.03
Melilotus alba	0.00	0.67	0.02	0.00	0.02
Urtica dioica	0.03	4.77	0.11	0.06	0.20

[a] $\text{Relative density} = \dfrac{\text{density for species}}{\text{total density for all species}}$

$\text{Density} = \dfrac{\text{number individuals}}{\text{area sampled}}$

$\text{Relative frequency} = \dfrac{\text{frequency for species}}{\text{total frequency values for all species}}$

$\text{Frequency} = \dfrac{\text{number of plots species occurred}}{\text{total number of plots}}$

% cover = % of sample area covered by given species

$\text{Relative \% of cover} = \dfrac{\text{\% cover for species}}{\text{total \% cover for all species}}$

Importance value = relative density + relative % cover + relative frequency

Table H16. Summary of Herbaceous Vegetation, West Sugar Island #1, 1979.

Species	Vegetation parameters[a]				
	Relative density	Standard deviation	Relative frequency	Relative % cover	Importance value
Carex sp.	0.11	23.87	0.06	0.05	0.22
Impatiens capensis	0.23	29.08	0.16	0.26	0.65
Taraxacum officinale	0.00	0.63	0.03	0.04	0.07
Barbarea vulgaris	0.00	1.58	0.03	0.04	0.07
Rumex mexicanus	0.00	0.32	0.03	0.01	0.04
Melilotus officinalis	0.02	7.24	0.06	0.02	0.10
Lysimachia terristris	0.02	6.96	0.03	0.01	0.06
Glyceria sp.	0.42	59.40	0.16	0.09	0.67
Polygonum sp.	0.02	6.64	0.03	0.01	0.06
Solidago sp.	0.03	6.51	0.13	0.02	0.18
Salix interior	0.07	7.54	0.22	0.32	0.61
Poa pratensis	0.06	18.96	0.03	0.11	0.20
Potentilla recta	0.00	0.32	0.03	0.01	0.04

[a]Relative density = $\frac{\text{density for species}}{\text{total density for all species}}$

Density = $\frac{\text{number individuals}}{\text{area sampled}}$

$$\text{Relative frequency} = \frac{\text{frequency for species}}{\text{total frequency values for all species}}$$

$$\text{Frequency} = \frac{\text{number of plots species occurred}}{\text{total number of plots}}$$

% cover = % of sample area covered by given species

$$\text{Relative \% of cover} = \frac{\text{\% cover for species}}{\text{total \% cover for all species}}$$

Importance value = relative density + relative % cover + relative frequency

Table H17. Summary of Herbaceous Vegetation, West Sugar Island #2, 1979.

Species	Vegetation parameters[a]				
	Relative density	Standard deviation	Relative frequency	Relative % cover	Importance value
Salix interior	0.18	6.38	0.14	0.65	0.97
Hieracium aurantium	0.09	12.13	0.07	0.06	0.22
Solidago sp.	0.04	5.78	0.12	0.03	0.19
Unidentified grass	0.21	43.07	0.07	0.03	0.31
Equisetum sp.	0.22	21.32	0.12	0.09	0.43
Galium borcycle	0.17	18.67	0.12	0.06	0.35
Taraxacum officinale	0.02	1.94	0.09	0.03	0.14
Latuca canadensis	0.06	8.28	0.12	0.03	0.21
Red Clover	0.01	0.82	0.07	0.01	0.09
Populus tremuloides	0.00	0.41	0.02	0.00	0.02
Trifolium agrarium	0.00	0.82	0.02	0.00	0.02
Barbarea vulgaris	0.00	0.41	0.02	0.00	0.02
Verbascum thaspus	0.00	0.41	0.02	0.01	0.03

[a]Relative density = $\frac{\text{density for species}}{\text{total density for all species}}$

Density = $\frac{\text{number individuals}}{\text{area sampled}}$

$$\text{Relative frequency} = \frac{\text{frequency for species}}{\text{total frequency values for all species}}$$

$$\text{Frequency} = \frac{\text{number of plots species occurred}}{\text{total number of plots}}$$

% cover = % of sample area covered by given species

$$\text{Relative \% of cover} = \frac{\text{\% cover for species}}{\text{total \% cover for all species}}$$

Importance value = relative density + relative % cover + relative frequency

Table H18. Summary of Herbaceous Vegetation, Northwest Sugar Island - 1979.

Species	Vegetation parameters[a]				
	Relative density	Standard deviation	Relative frequency	Relative % cover	Importance value
Solidago sp.	0.04	10.88	0.10	0.09	0.23
Cirsium arvense	0.07	11.38	0.10	0.25	0.42
Taraxacum officinale	0.02	3.70	0.10	0.03	0.15
Latuca canadensis	0.02	2.95	0.13	0.06	0.21
Equisetum sp.	0.32	44.15	0.13	0.27	0.72
Phleum pratensis	0.01	3.57	0.03	0.00	0.04
Barbarea vulgaris	0.03	8.44	0.10	0.05	0.18
Chrysanthemum leucanthemum	0.01	4.28	0.08	0.03	0.12
Glyceria grandis	0.06	14.14	0.08	0.03	0.17
Cirsium vulgare	0.00	0.45	0.03	0.04	0.07

[a]Relative density = $\frac{\text{density for species}}{\text{total density for all species}}$

Density = $\frac{\text{number individuals}}{\text{area sampled}}$

Relative frequency = $\frac{\text{frequency for species}}{\text{total frequency values for all species}}$

Frequency = $\frac{\text{number of plots species occurred}}{\text{total number of plots}}$

% cover = % of sample area covered by given species

$$\text{Relative \% of cover} = \frac{\text{\% cover for species}}{\text{total \% cover for all species}}$$

Importance value = relative density + relative % cover + relative frequency

Table H19. Summary of Herbaceous Vegetation, Middle 6 Mile Island - 1980.

Species	Vegetation parameters[a]				
	Relative density	Standard deviation	Relative frequency	Relative % cover	Importance value
Glyceria grandis	0.42	20.12	0.25	0.32	0.99
Phalaris arundinacea	0.30	14.30	0.25	0.37	0.92
Polygonum amphibium	0.29	8.67	0.50	0.31	1.10

[a]Relative density = $\frac{\text{density for species}}{\text{total density for all species}}$

Density = $\frac{\text{number individuals}}{\text{area sampled}}$

Relative frequency = $\frac{\text{frequency for species}}{\text{total frequency values for all species}}$

Frequency = $\frac{\text{number of plots species occurred}}{\text{total number of plots}}$

% cover = % of sample area covered by gi'en species

Relative % of cover = $\frac{\text{\% cover for species}}{\text{total \% cover for all species}}$

Importance value = relative density + relative % cover + relative frequency

Table H20. Summary of Herbaceous Vegetation, Steamboat Island - 1979.

Species	Vegetation parameters[a]				
	Relative density	Standard deviation	Relative frequency	Relative % cover	Importance value
Impatiens capensis	0.96	94.50	0.40	0.90	2.26
Lysimachia terrestris	0.00	1.00	0.10	0.00	0.10
Urtica dioica	0.02	9.68	0.30	C.05	0.37
Barbarea vulgaris	0.02	10.00	0.10	0.01	0.13
Verbascum thaspus	0.00	1.00	0.10	0.03	0.13

[a]Relative density = $\frac{\text{density for species}}{\text{total density for all species}}$

Density = $\frac{\text{number individuals}}{\text{area sampled}}$

Relative frequency = $\frac{\text{frequency for species}}{\text{total frequency values for all species}}$

Frequency = $\frac{\text{number of plots species occurred}}{\text{total number of plots}}$

% cover = % of sample area covered by given species

Relative % of cover = $\frac{\text{\% cover for species}}{\text{total \% cover for all species}}$

Importance value = relative density + relative % cover + relative frequency

APPENDIX I. GREAT LAKES BEACHED BIRD SURVEY FORMS AND INSTRUCTIONS

GREAT LAKES BEACHED BIRD SURVEY

c/o Long Point Bird Observatory
P.O. Box 160
Port Rowan, Ontario NOE 1MO
Canada

INSTRUCTION SHEETS 2ND EDITION

1) Choose a beach which is convenient and accessible to you. It should be one you find enjoyable to walk so that the survey doesn't become a chore.

2) Pick a length of beach suitable for you to walk. It should be about two miles in one stretch although shorter beaches are acceptable. Walk the same strip of beach each survey.

3) After you have chosen your beach, fill out and send in the registration form. You will be mailed a beach registration number which you should use on all your correspondence and survey forms (upper right-hand corner). Once you have this number you can begin your surveying.

4) Survey trips should be made either once a month or twice a month. There should be a minimum of 10 days between any 2 walks. The surveying continues year-round, and we recommend - but this is optional - that you continue surveys in winter even at shoreline that freezes over (preventing beaching of birds), in order to do live waterbird counts (see (13)). If the beach is in an urban area or a park, try to determine if it is 'cleaned' by maintenance staff. Beaches which are frequently cleaned are not desireable for surveys, but you may be able to contact the staff and have them save the birds found during their 'cleaning'. These birds should be recorded on the survey forms with the date they were picked up.

5) Look for bird carcasses along the water's edge and higher up on the beach among high water debris. Most carcasses will probably be found after storms with onshore winds. Record all kinds of bird carcasses found (i.e. including songbirds, ducks, shorebirds, etc.).

6) For each carcass determine as much information as possible (i.e: species, age, sex, condition, cause of death, etc.) and record it on the survey form. You should inspect all carcasses for bands (record number), oil and cause of death. If the bird is fresh you may be able to feel the breastbone and note if the bird was starving. Also note any parts of birds found (i.e. wings or skulls).

7) Identification of carcasses to species, age or sex can be tricky. A field guide will help but often the diagnostic features may be hard to see. Identify them as specifically as possible. For some birds you may only be able to record that it's a duck or a gull. If you cannot identify a carcass to species write a description of it on the survey form and note size, color, shape of bill, feet and wing and take measurements if possible.

8) The following list of books, obtainable from a local library or bookstore or by mail from the F.O.N. Nature Bookstore, 46 Elgin St., Ottawa, Ont. KIP 5K6, may help with identification problems:

Please turn over.

Birds of North America - Robbins, Brunn, Zim and Singer
--good pictures, range maps and brief descriptions
A Field Guide to the Birds (Eastern) - Peterson
--good pictures, field marks and descriptions
The Birds of Canada - Godfrey
--measurements, range maps and lengthier descriptions
Ducks, Geese and Swans of North America - Bellrose
--measurements, maps and detailed descriptions

9) Once you have recorded all the information from a carcass dispose of it by throwing or burying it above the high water mark so that it will not be recorded again.

10) If you come across uncommon species like jaegers or sea ducks they should be saved for skeletal specimens if not too much trouble. They are of scientific value for documenting records and can aid in identifying other carcasses. If the carcasses are dessicated, they can be wrapped in newspaper, put in plastic bags and packed in a box. Ship them with information on their origin to the coordinator. If the carcasses are fresh & you have room in a freezer they should be wrapped in two or three plastic bags and frozen. Write the coordinator and pickup will be arranged.

11) Be sure to follow the instructions at the top of the survey forms and use the codes as indicated. Note on the form that you have done a walk even if nothing is found. After entering a survey on the form draw a line on the form after the entry to separate it from the next entry.

12) The age codes to be used on the survey forms are HY, AHY, SY, ASY, TY, ATY or U. These codes are based on the calendar year and allow a precise designation of age. They are defined as follows:

HY-hatching year-a bird hatched during the calendar year in which it was found (Ex. Hatched 1977 - Found on survey 1977)
AHY-after hatching year- a bird hatched before the calendar year in which it was found (Ex. Hatched in or before 1976 - Found on survey 1977)
SY-second year- a bird known to have hatched in the calendar year preceding the year in which it was found (Ex. Hatched 1976 - Found on survey 1977)
ASY-after second year-a bird known to have hatched earlier than the calendar year preceding the year in which it was found (Ex. Hatched in or before 1975 - Found on survey 1977)
TY-third year-defined similar to SY except that bird hatched in the calendar year two years previous to the year in which it was found.
ATY-after third year-defined similar to ASY except that bird hatched earlier than two years previous to year in which it was found
U-unknown

Use the most precise code possible. Most birds will be aged as HY or AHY but with some gulls and terns more exact aging is possible. Participants will receive a key to identifying and ageing gulls, and any other keys we make up.

Cont.

Instruction Sheet, Cont.

13) Live waterbird counts. On each walk make two to four stops, according to the schedule below, to count all live waterbirds (loons, grebes, ducks, geese, swans, coots, rails, herons, gulls, terns, shorebirds, etc.).

route length	number of stops/counts	position on route of stops
1 mile or less	2	beginning and end
between 1 and 3 miles	3	beginning, middle, and end
3 miles or over	4	beginning, 1/3 way, 2/3 way, end

At each stop, scan the water, ice and land areas visible in all directions from that stop, once only. Count all sitting and standing waterbirds together with those flying over while you are scanning the area, and record them in the respective 'activity' category on the waterbird count sheets. If possible, use binoculars. If identification to species is not possible, try to identify and count birds in families (e.g. "gulls", "ducks", "loons", etc.). Do not count birds which are too distant to identify even to family using binoculars (rather than telescopes). This criterion delineates the size of the count area. Next, fill out the questions on viewing conditions and ice conditions. See the example waterbird count sheet on the reverse of of this page. If no birds are in sight at a stop, continue the walk without waiting, but be sure to record the stop (and ice conditions) on the sheets.

Important note: For any beach routes in which ice conditions are affected by man-made causes, such as shipping or thermal discharges from industrial plants and mills, please let us know about it in a special note (which you can send along with your survey forms). Live waterbird counts at any such areas (including those away from your regular routes) are appreciated - even if it is only a one-time count. Just record the location and date and send in the additional information with your other forms.

14) Send in four months of survey forms (beached bird and live waterbird count forms) promptly at the end of April, August, and December each year to: Beach Survey, Long Point Bird Observatory, P.O. Box 160, Port Rowan, Ontario NOE 1MO, Canada. If you need more forms or have any questions write to the coordinator at this address.

* * * *

Date:________________ Count: 1st 2nd 3rd 4th Binoculars used? yes no

Viewing conditions (lighting and visibility): poor fair good

Ice conditions (circle one): (a) no ice
(b) complete ice cover
(c) ice and open water - CONTINUE ↓

(c) ice and open water
1. Does ice prevent beaching of birds? yes no
2. Distance from shore to open water (i.e. width of ice at shore):__________
3. Is open water (a) extensive, or (b) in patches?

SPECIES	number observed in each category						
	flying over water	flying over land	flying over ice	sitting on water	sitting or standing on land	sitting or standing on ice	other -
ng-billed Gull							
Herring Gull							

Date:________________ Count: 1st 2nd 3rd 4th Binoculars used? yes no

Viewing conditions (lighting and visibility): poor fair good

Ice conditions (circle one): (a) no ice
(b) complete ice cover
(c) ice and open water - CONTINUE ↓

(c) ice and open water
1. Does ice prevent beaching of birds? yes no
2. Distance from shore to open water (i.e. width of ice at shore):__________
3. Is open water (a) extensive, or (b) in patches?

SPECIES	number observed in each category						
	flying over water	flying over land	flying over ice	sitting on water	sitting or standing on land	sitting or standing on ice	other -
g-billed Gull							
erring Gull							

reat Lakes Beached Bird Survey LIVE WATERBIRD COUNT SHEET Beach:________________ No.____

Date:________________ Count: 1st 2nd 3rd 4th Binoculars used? yes no

Viewing conditions (lighting and visibility): poor fair good

Ice conditions (circle one): (a) no ice
(b) complete ice cover
(c) ice and open water - CONTINUE ↓

(c) ice and open water
1. Does ice prevent beaching of birds? yes no
2. Distance from shore to open water (i.e. width of ice at shore):____________
3. Is open water (a) extensive, or (b) in patches?

SPECIES	number observed in each category						
	flying over water	flying over land	flying over ice	sitting on water	sitting or standing on land	sitting or standing on ice	other -
ng-billed Gull							
Herring Gull							

Date:________________ Count: 1st 2nd 3rd 4th Binoculars used? yes no

Viewing conditions (lighting and visibility): poor fair good

Ice conditions (circle one): (a) no ice
(b) complete ice cover
(c) ice and open water - CONTINUE ↓

(c) ice and open water
1. Does ice prevent beaching of birds? yes no
2. Distance from shore to open water (i.e. width of ice at shore):____________
3. Is open water (a) extensive, or (b) in patches?

SPECIES	number observed in each category						
	flying over water	flying over land	flying over ice	sitting on water	sitting or standing on land	sitting or standing on ice	other -
ng-billed Gull							
Herring Gull							

Beach: ______________________________ No. ______

Use key and instructions as described on other side.

DATE	SPECIES	AGE	SEX	CONDITION	CAUSE OF DEATH	REMARKS

Send in preceding four months of surveys promptly at the end of April, August and December to the address at the top of other side. Check here if you have used all your forms and need more.

GREAT LAKES BEACHED BIRD SURVEY
c/o Long Point Bird Observatory
P.O. Box 160
Port Rowan, Ontario NOE 1MO, Canada

Beach: ______________________________ **No.** ______

Observers: ______________________________

Key: Date: day/month/year
Species: Be as specific as possible (Ex. If unknown duck, put 'unknown duck').
Age: HY, AHY, SY, ASY, TY, ATY, U; See instruction sheet (#11) for explanation.
Sex: F - female, M - male, leave blank if unknown
Condition: 0 - barely alive, 1 - fresh, 2 - decomposing, 3 - dessicated
Cause of death: oiled, shot, tangled in fishing line, etc., blank if unknown
Remarks: oil on beach, color phase of bird, description of unknown carcass, etc.

Draw a line between surveys. N.B. Record that survey was done even if no carcasses found

DATE	SPECIES	AGE	SEX	CONDITION	CAUSE OF DEATH	REMARKS

GREAT LAKES BEACHED BIRD SURVEY

Registration Form

Fill out and return as soon as possible to: Beach Survey, Long Point Bird Observatory, P.O. Box 160, Port Rowan, Ontario NOE 1M0 Canada

) Name ____________________ 2) Date ________ 198__

Address ____________________ Phone: ____________

____________ ________ Postal/Zip Code ________

) Beach ____________________ (pick a short name to identify the beach on your survey forms)

Location ____________________ (include distance and direction of nearest town or enclose a map)

Lake (circle one) Superior Michigan Huron St. Clair Erie Ontario
or River: St. Marys Detroit St. Clair St. Lawrence

) Length of survey (to nearest tenth of a mile, use a map if necessary) ______ miles

From ____________________
(be specific)
To ____________________

If this includes shoreline at which beaching of birds is not possible (e.g. seawall), what is the length of this shoreline? ________ miles

) Description of beach (% of beach edge which consists of the following)

_____ sand _____ pebbles _____ rocks or breakwater _____ grass or aquatic plants

_____ mud Other _____ (describe) ________

Average width of beach (in feet) ________

Orientation of beach (circle one) N-S NE-SW E-W SE-NW If more than one orientation draw a map of beach on back of this form including scale and north.

) Recreational uses of beach. Fill in amount and time of use for applicable recreational uses. Use the following codes:

Amount of use: 1) heavy (daily) 2) moderate (weekends) 3) light (occasionally)
Time of use: A) Spring B) Summer C) Fall D) Winter E) Year-round

Use	Amount	Time	Use	Amount	Time
Boating	____	____	Swimming	____	____
Camping	____	____	Walking dogs	____	____
Hunting	____	____	other ________	____	____
Picnicing	____	____	________	____	____

Is it likely that humans, dogs or other animals are removing beached birds? _____

If yes, explain: ____________________

7) Are there colonies of birds within a mile of the beach ? ______ If yes, are they nesting or roosting? ________ What kinds of birds? ________

8) Any additional information about beach (such as, is it a landfill?, shoreline is being changed or developed, etc.) should be recorded briefly on other side.

EXAMPLE

Date: Dec 3/79 Count: 1st 2nd 3rd 4th Binoculars used? yes no

Viewing conditions (lighting and visibility): poor fair good

Ice conditions (circle one): (a) no ice
(b) complete ice cover
(c) ice and open water - CONTINUE ↓

(c) ice and open water
1. Does ice prevent beaching of birds? yes no
2. Distance from shore to open water (i.e. width of ice at shore): 30 m (20-5
3. Is open water (a) extensive, or (b) in patches?

SPECIES	number observed in each category						
	flying over water	flying over land	flying over ice	sitting on water	sitting or standing on land	sitting or standing on ice	other -flying ice + wat
Ring-billed Gull	30, 5, 2	2				~120	
Herring Gull					1		
Oldsquaw				11, 2			
Duck	3					15	
Killdeer					1 (at shore)		
Mallard				3			
Canada Goose							8 or 9
Teal (unid.)				2			

Date: Dec 3/79 Count: 1st 2nd 3rd 4th Binoculars used? yes no

Viewing conditions (lighting and visibility): poor fair good

Ice conditions (circle one): (a) no ice
(b) complete ice cover
(c) ice and open water - CONTINUE ↓

(c) ice and open water
1. Does ice prevent beaching of birds? yes no
2. Distance from shore to open water (i.e. width of ice at shore): ___________
3. Is open water (a) extensive, or (b) in patches?

SPECIES	number observed in each category						
	flying over water	flying over land	flying over ice	sitting on water	sitting or standing on land	sitting or standing on ice	other -
Ring-billed Gull	25						
Herring Gull							
Gull	14 100 5			30			
Duck	~20						
Duck	10-15, 3						
Loon	1						